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TYPES OF VESICAL NECK OBSTRUCTION SUITED TO INTRAURETHRAL RESECTION: ADVANTAGES OF TREATMENT BY THE ROTARY PROSTATIC RESECTOSCOPE*

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THE popularity of intraurethral excision of obstructions at the neck of the bladder has led to many ill-advised interventions in that region, and made it evident that a careful selection of cases is an absolute prerequisite to success with this particular therapy. Because the present trend in urological work is away from open operation upon cases of urinary obstruction, many patients who could not be relieved without it have been subjected to inadequate, or actually damaging treatment. For this reason a highly useful procedure has been brought into undeserved disrepute.

A thorough study of the different types of vesical neck obstruction and careful consideration of the individual patient as he presents himself for the surgeon's examination, should be sufficient guide to selection of the method most appropriate to each particular case. There should never be any question of *replacing* prostatectomy by intraurethral excision. Many cases of vesical neck obstruction with residual urine can be relieved without resort to open operation. Others could be more satisfactorily treated by perineal or suprapubic prostatectomy, but cannot undergo open operation without too great risk, owing to some complicating condition: senility, auricular fibrillation, renal impairment and so on. Beside these we frequently see "borderline" cases, where it requires good surgical judgment to decide whether intraurethral excision of obstructing tissue will be sufficient, or only enucleation of the entire hypertrophied mass will provide a satisfactory solution of the problem.

As with most surgical problems, experience is our best teacher, but it is sometimes possible for one to hand on the results of his experience to others, thereby saving them much of the trouble and expense attending the trial-and-error method. After several years' endeavor to standardize the requirements, I have formed a fairly complete picture of the types of vesical neck obstruction which are, or are not, suited to intraurethral treatment. With the efficient aid of the artist, Mr. William P. Didusch, I have been able to obtain excellent views of representative obstructions at the bladder neck, and to make a careful study of the pathology in each typical case. The conditions at the vesical neck are represented from two angles; from above, using a right angle lens through a suprapubic incision; and also intraurethrally, by the employment of the McCarthy foroblique telescope. This presents an unusually accurate representation of the pathological conditions obtain-

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ing in different types of urinary obstruction without enlargement of the prostate.

In Figure 1 we have two views of contracture of the bladder neck. In (1) the condition is shown as it appears on cystoscopic inspection. In (2) the observer is looking down upon the vesical neck, seeing the contracted tissues as they appear when viewed through a suprapubic incision.

In Figure 2 is seen a typical median bar obstruction without hypertrophy of the prostate. The obstructive mechanism set up by the bar is admirably shown. Figure 3 represents a slightly enlarged median lobe; sagittal section clearly indicates the relation between this lobe and the vesical orifice, explaining the symptoms of frequency and urgency of which the patient

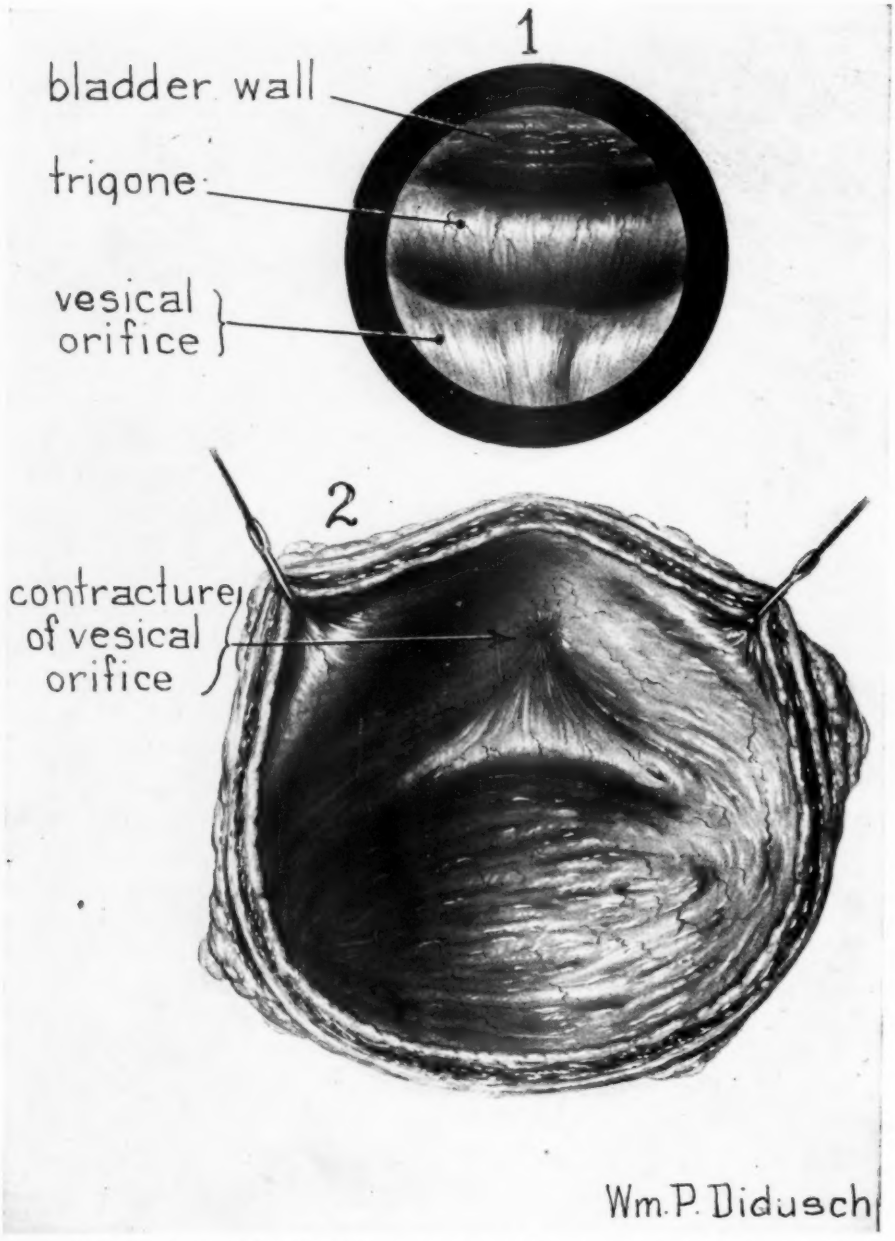

Fig. 1. Contracture of the vesical neck. (1) Cystoscopic view of contracture. (2) View of the opened bladder from above.

complains, which will, of course, increase with extension of the lesion.

In Figure 4 is seen a case of moderate hypertrophy is considerably greater than that exhibited in the preceding figure. The slight intraurethral intrusion of the lateral

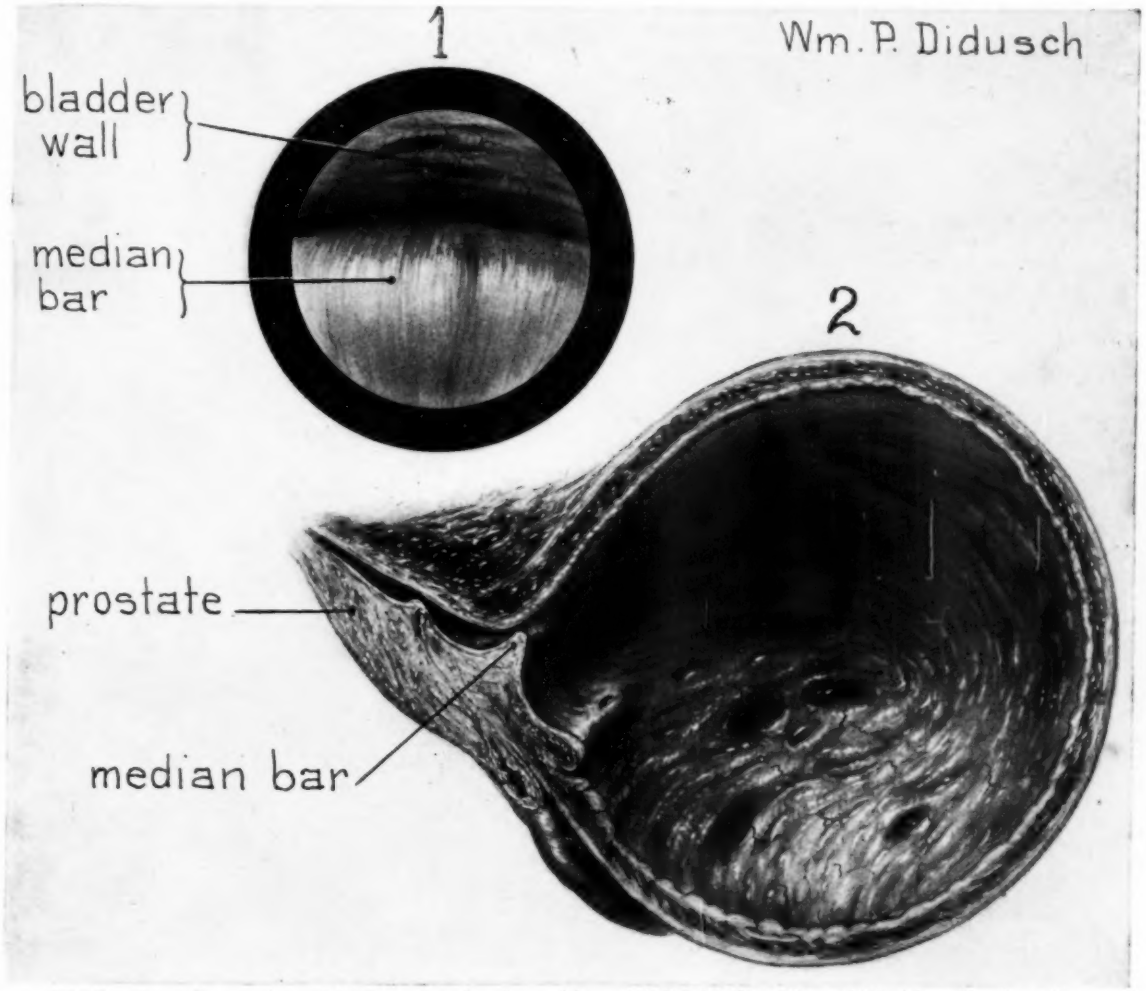

Fig. 2. Median bar obstruction. (1) Cystoscopic view of bar. (2) Sagittal section of bladder showing obstruction by bar.

median lobe enlargement, with very slight lateral lobe hypertrophy. In such cases the residual urine will vary in amount from 8 c.c. (2 drams) to 45 c.c. (1½ oz.), with the usual symptoms of frequency and urgency, which will be aggravated by long automobile or train rides. The condition shown here is not, however, so greatly advanced as to be unsuited to intraurethral intervention.

An equal degree of median lobe enlargement is seen in Figure 5. Here we have also slight enlargement of the lateral lobes, so that the resulting mass of tissue lobes is not yet sufficient to make the case unsuited to resection, for the use of the resectoscope has given relief from the usual symptoms in a large number of such cases.

Median lobe hypertrophy is still moderate in the condition shown in Figure 5, but the intraurethral intrusion of the lateral lobes is so marked as to render anything other than open operation extremely hazardous, and the end-results unsatisfactory. With so great a mass of tissue present intraurethral methods cannot be recommended. Figure 7 shows

hypertrophy still more advanced than in the preceding figure although the lateral lobe enlargement is not so great as that

Toronto I devoted a good part of my time to showing pathological slides demonstrating the poor end-results following

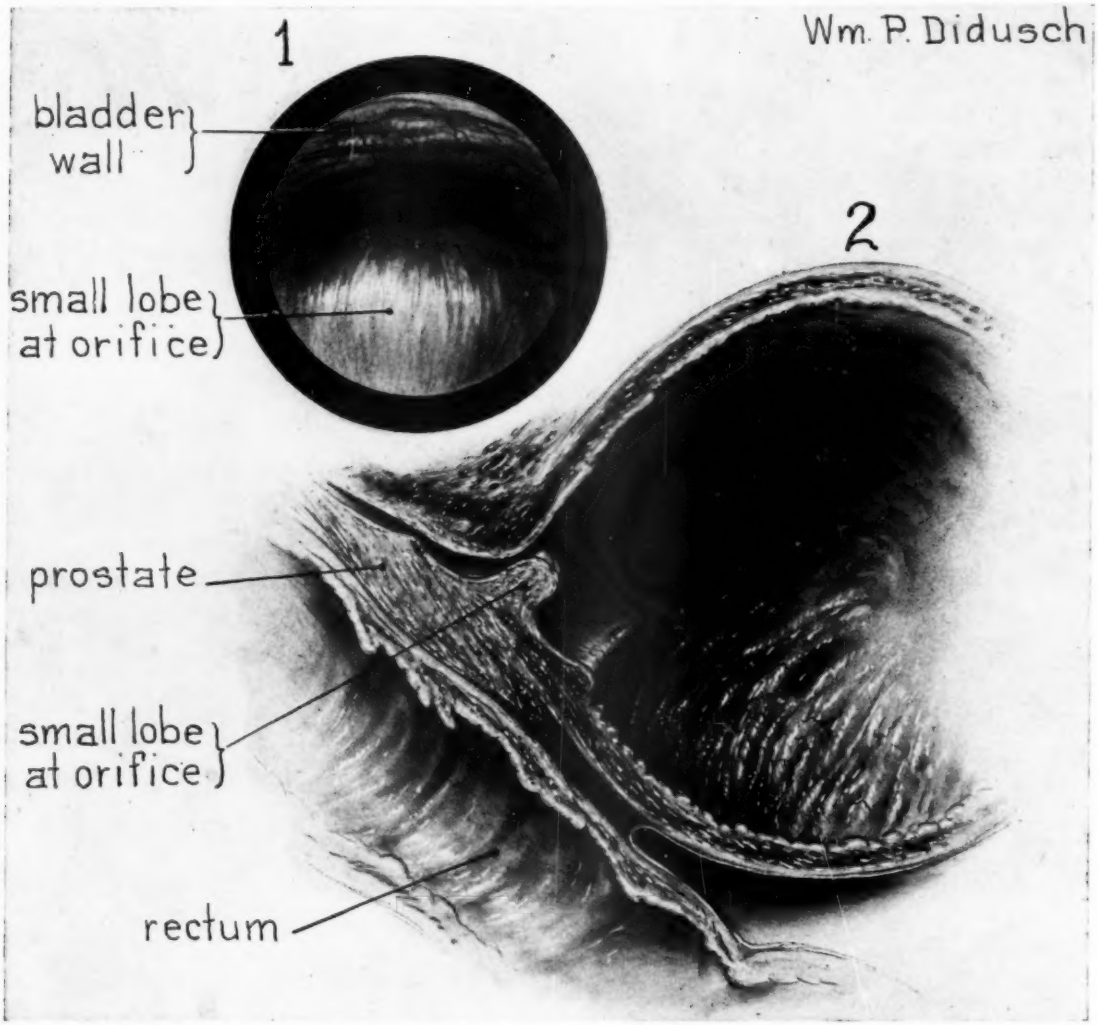

Fig. 3. Slightly enlarged median lobe. (1) Cystoscopic view. (2) Sagittal section showing location of lobe in relation to vesical orifice.

appearing in Figure 8. In this picture all three lobes have reached proportions reducible only by open operation. Close inspection of the types of cases shown in these last three figures should convince any operator that no instrument so far devised for intraurethral work could cope with them successfully. Throughout the years which I have devoted to this work I have repeatedly emphasized the impossibility of *substituting* intraurethral resection for prostatectomy. In the presentation of my work which I made a few months ago at

indiscriminate use of the intraurethral method, and the limitations which circumscribe the method. I have under my care at present two patients who were referred to me for intraurethral resection. Examination showed the obstruction at the vesical neck to be too large to be treated by this means, so I advised prostatectomy. Both men declined my advice, returned to their own physicians and underwent intraurethral operation elsewhere. Later they came back again to me, both with recurrence of the original trouble in an

aggravated form, one with complete retention and the other carrying a large residual urine. The prostatectomy which each must now undergo will be complicated and rendered more dangerous by the presence of the scar-tissue left by the preceding vesical neck resection.

INDICATIONS FOR THE USE OF THE INTRAURETHRAL METHOD

Such careful study of the conditions here shown as has been advocated, inevitably leads to the conclusion that the method under consideration is applicable only to a definitely limited set of conditions. Within those limits its usefulness is very evident. Briefly the indications for resection by this route, according to my experience , are as follows:

1. Contracted bladder neck
2. Median bar obstruction
3. Intrusion of enlarged middle lobe, with slight lateral lobe intrusion
4. Subcervical gland hypertrophy causing frequency
5. Obstruction due to carcinoma of the prostate
6. Congenital valves of the urethra
7. Slightly enlarged lateral lobes without median lobe enlargement
8. Senile patients unable to undergo open operation. Even in this type of case, if the lesion corresponds to the pathological conditions shown in Figures 6, 7, and 8, it would be better to prepare the patient with extra care and perform cystotomy; then, if the general condition can be made to warrant it, a prostectomy, rather than to attempt resection by the intraurethral route.
9. Conditions of marked renal impairment; grave heart lesions such as auricular fibrillation, or other constitutional disabilities which cannot be removed by suitable preoperative treatment. Here the aim must be merely to establish drainage.

CONTRAINDICATIONS TO THE INTRAURETHRAL PROCEDURE

As has already been pointed out, the ability to judge when a patient should *not* be subjected to the intraurethral procedure is of quite as much importance as the possession of the skill requisite to apply

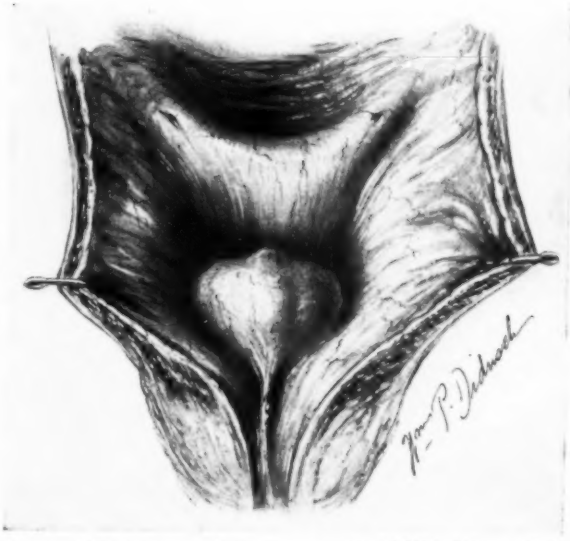

Fig. 4. Moderate enlargement of middle lobe; slight hypertrophy of lateral lobes. Case well suited for radiothermic resection.

the technique successfully when it *is* indicated. No instrument as yet devised is capable of dealing adequately with an advanced degree of prostatic hypertrophy, notwithstanding the fact that many of them have repeatedly been used for that purpose. Extensive enlargement of all the lobes offers, I am convinced, an insurmountable barrier to successful intraurethral resection. I am most emphatically of the opinion that this method should not be employed:

1. In the presence of great median lobe hypertrophy, such as is shown in Figure 8.
2. In marked enlargement of both lateral lobes, even though the middle lobe is not enlarged. Marked lateral lobe intrusion into the urethra contraindicates the procedure, even though the middle lobe be shrunken and sclerotic (see Fig. 6).
3. When both median and lateral lobes are so hypertrophied as to constitute a formidable mass of tissue, even though the size of any one lobe is not so great as described in (1) and (2). In this pathological type more than in any other, good surgical judgment is required and experi-

ence is preeminently the best guide. Such a case is shown in Figure 7. This is the "borderline" case which so often betrays the surgeon's confidence in himself. Therefore, most careful weighing of all the factors involved is essential.

Speaking generally, it has been my experience that all untoward results have come to pass because I attempted *too large resections*. Hemorrhage is much more persistent and difficult to keep in check when a large amount of tissue must be removed, and the operation is rendered a greater risk because of the increased length of time required to excise so large a mass. Most of the instruments now in use for this purpose take very small "bites," so that attempts to remove obstructing lobes of large size have been known to consume more than two hours, decidedly too much strain to be placed upon the average subject of urinary retention due to vesical neck obstruction.

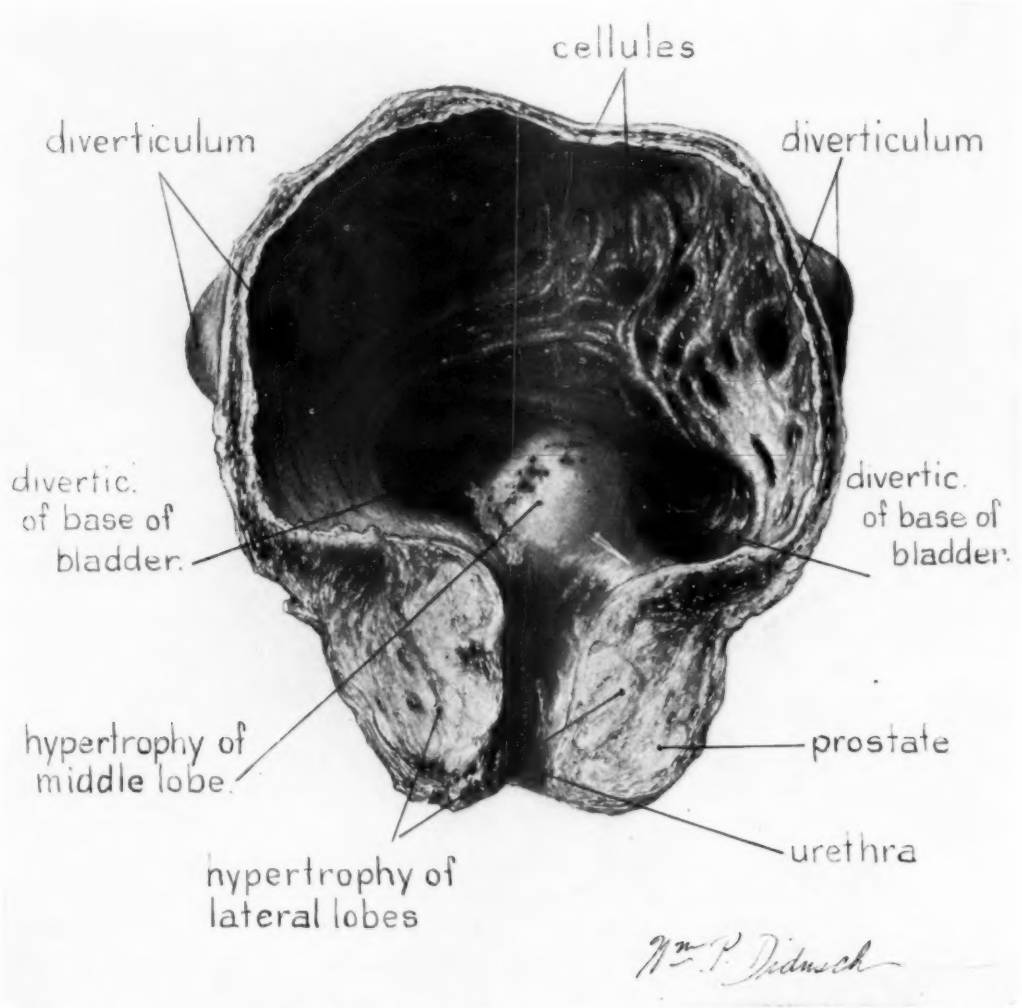

Fig. 5. Moderately enlarged middle lobe, with slight enlargement and intraurethral intrusion of lateral lobes. Hypertrophy not yet great enough to prevent satisfactory resection.

CONTROL OF HEMORRHAGE

As in prostatectomy by either the perineal or suprapubic route, the control of hemorrhage constitutes one of the major problems of intraurethral resection. For this purpose the electric cautery was early combined with instruments for resection, the cystoscopic features of the

armament being still later additions. In working upon the various aspects of this problem, it soon became evident to me that better control of the cautery feature of the instrumentation would greatly reduce the postoperative complications due to the use of too great heat, in particular the sloughing of damaged tissue, to which most postoperative hemorrhage is directly attributable. In an earlier communication I called attention,[1] so far as I am aware, for the first time, to the advisability of using only low amperage in any form of galvanocautery excision. When high temperatures are brought into service, the effects of the heat are felt much beyond the area actually resected. The fluid in the tissues immediately affected is converted into steam which scalds and otherwise damages the surrounding bladder neck. There follows sloughing, cicatrization and, eventually, contraction of the tissues. These unfortunate sequelae can be obviated by the employment of radiothermy with low amperage. Low heat is just as effective in closing up the lumina of the severed blood vessels, and as this is the primary purpose in employing the electric current in vesical neck resection, there is no reason to use anything fraught with such potential dangers as the high temperatures so often put into service in the intraurethral procedure.

In all the devices now available for electrocautery resection the thermic feature is, of course, introduced for the purpose of sealing the blood vessels which would otherwise contribute to dangerous or even fatal hemorrhage. The mechanism by which this is accomplished varies considerably. In some heat is used *after* the cutting has been done by the surgeon's knife, but under these circumstances as well it is exactly as efficient to raise the temperature only enough to *close* the vessels, not to *cook* them. When electric cutting is done, it may or may not have hemostatic effect. Therefore, even when the electrocautery knife is used, it may be necessary to have recourse to radioheat sufficient to stop the bleeding.

Fig. 6. Moderate hypertrophy of middle lobe, but such marked intraurethral enlargement of lateral lobes as to leave no room for manipulation of the resectoscope. Such cases must be subjected to prostatectomy.

The McCarthy radiogenerator now generally employed does not arc over the surface of the electrode as did the current from the earlier designed *spark-gap* generators. The rapid carbonization of all spark-gap type of machines does not, therefore, take place, and a highly selective heat is obtainable. If the heat be continued at low amperage after the albumin in the blood vessels has been coagulated, the tissues will gradually shrivel down into a mass so hard that neither absorption of septic material nor sloughing can take place, while incrustation quickly follows. Rapid absorption and the tissue necrosis which induces sloughing are conditioned by a small soft coagulum.

Sufficient consideration has never been given to the condition of the tissues surrounding the site of resection which are left after the excised tissue has been removed. Most of the suggested methods take absolutely no account of this. Consequently, sloughing and secondary hemorrhage in areas outside the actual site of excision and cauterization are of frequent occurrence. While they may not have come

[1] *Surg., Gynec. Obst.*, 52: 1007, 1931.

in direct contact with the heat of the electrode, the steam generated in the tissues which the electrode did touch

Fig. 7. Great enlargement of middle lobe, accompanied by considerable hypertrophy of lateral lobes; resulting mass of tissue is too great to be handled successfully by the intraurethral method.

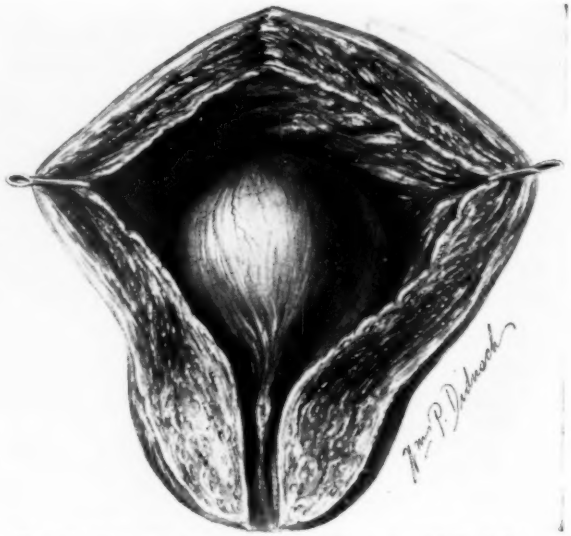

Fig. 8. Tremendous hypertrophy of middle lobe, with marked intraurethral enlargement of both lateral lobes. Prostatectomy is the procedure of choice for all such conditions.

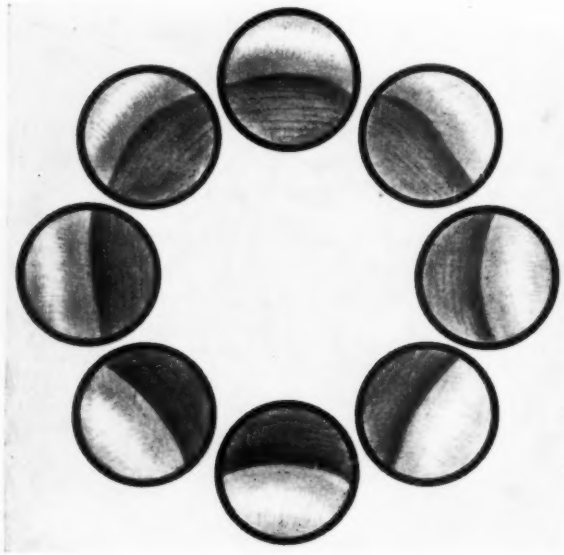

Fig. 9. Cystoscopic appearance in Case 1, prior to operation. Moderate enlargement of middle lobe and lateral lobes. Residual urine, 3 ounces.

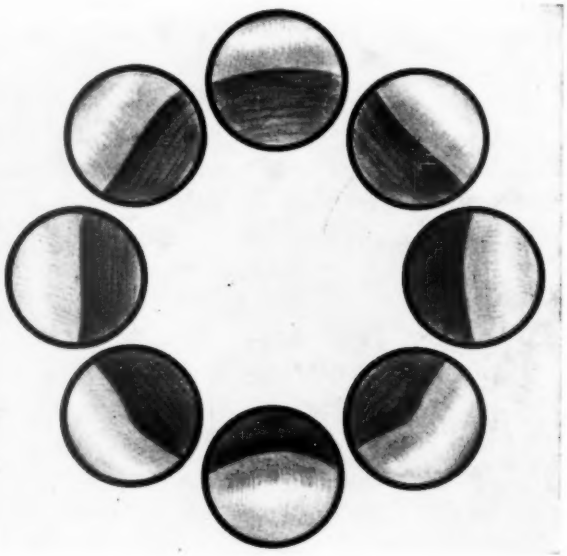

Fig. 10. Cystoscopic appearance in Case 11. Middle and lateral lobes moderately enlarged; residual urine, 6 ounces.

will scald them seriously, and in those devices where the actual cutting is not done under complete vision there is no guarantee that tissues pierced by the electrode will be entirely removed by the resector, or that trauma will not occur where the field of operation was not supposed to extend. Such injuries are minimized or overlooked entirely, yet to them must be attributed most of the unsatisfactory results following vesical

neck resection by some of the methods now in vogue.

DEFINITIONS

In my investigation of the effects of heat I have found myself faced with the necessity of establishing a new set of definitions for the terms regularly used in referring to the surgical employment of electricity. *Electrocoagulation* is the most commonly used designation. This is usually defined in medical dictionaries as "the effect produced in tissues by the application of a bipolar current delivered to an electrode." Dorland adds: "The tissue is broken down and condensed into a necrotic mass." Webster tells us that *coagulation* "is the changing from a liquid to a curdled state by chemical action." In much of the literature dealing with intraurethral operation the term "coagulation" is used very loosely, apparently with the idea of indicating *any* effect produced upon the tissues to which an electric current is applied. What is actually meant is a clotting of the albumin contained in those tissues. Anyone who has worked much with this comparatively new form of therapy will shortly realize that the range between the mild heat used in medical diathermia, and an amperage sufficient to carbonize tissue, is far too wide to be included in any single term such as "coagulation."

As a more elastic and comprehensive term I have called the result sought in thus using heat *radio-shrinkage*. The entire procedure of applying electric current to induce this shrinkage may, I think, appropriately be called *radio-thermatization*. This, in turn, may be still further modified by indicating the *degree* to which the process has been permitted to affect the tissues, borrowing the culinary terms *rare*, *medium* and *well-done*. If the radio-thermatization be carried to the "well-done" stage the chances of bad end-results are greatly enhanced. Not only is a wider area injured, but the deeper tissues are affected as well, so that induration and consequent delay in healing are sure to take place.

Fig. 11. Case III, as seen through cystoscope. Vesical neck obstruction by moderate enlargement of all three lobes. Nine ounces of urine remained after voiding, before resection was performed. After resection 1 dram only was retained.

SPECIAL APPLICATIONS OF RADIO-THERMATIZATION

Pursuing the study of this principle of *low heat*, I found that in certain types of hypertrophy the mere application of conservative shrinkage, without carrying out actual resection, reduced the mass obstructing the outflow of urine to such an extent that subsequent resection was unnecessary. There are many subjects of vesical neck obstruction who are obviously such poor risks, because of senility, cardiac lesions and so on, that one hesitates to put upon them even the slight strain of an intraurethral excision. These observations upon shrinkage led me to modify the apparatus which I employ, replacing the cutting wire electrode with a roller which I applied to the vesical neck in accordance with the same technique, *beating* the tissues but not *excising* them. It is still too soon to report any positive results from this modified procedure, as recurrence is the only criterion by which its

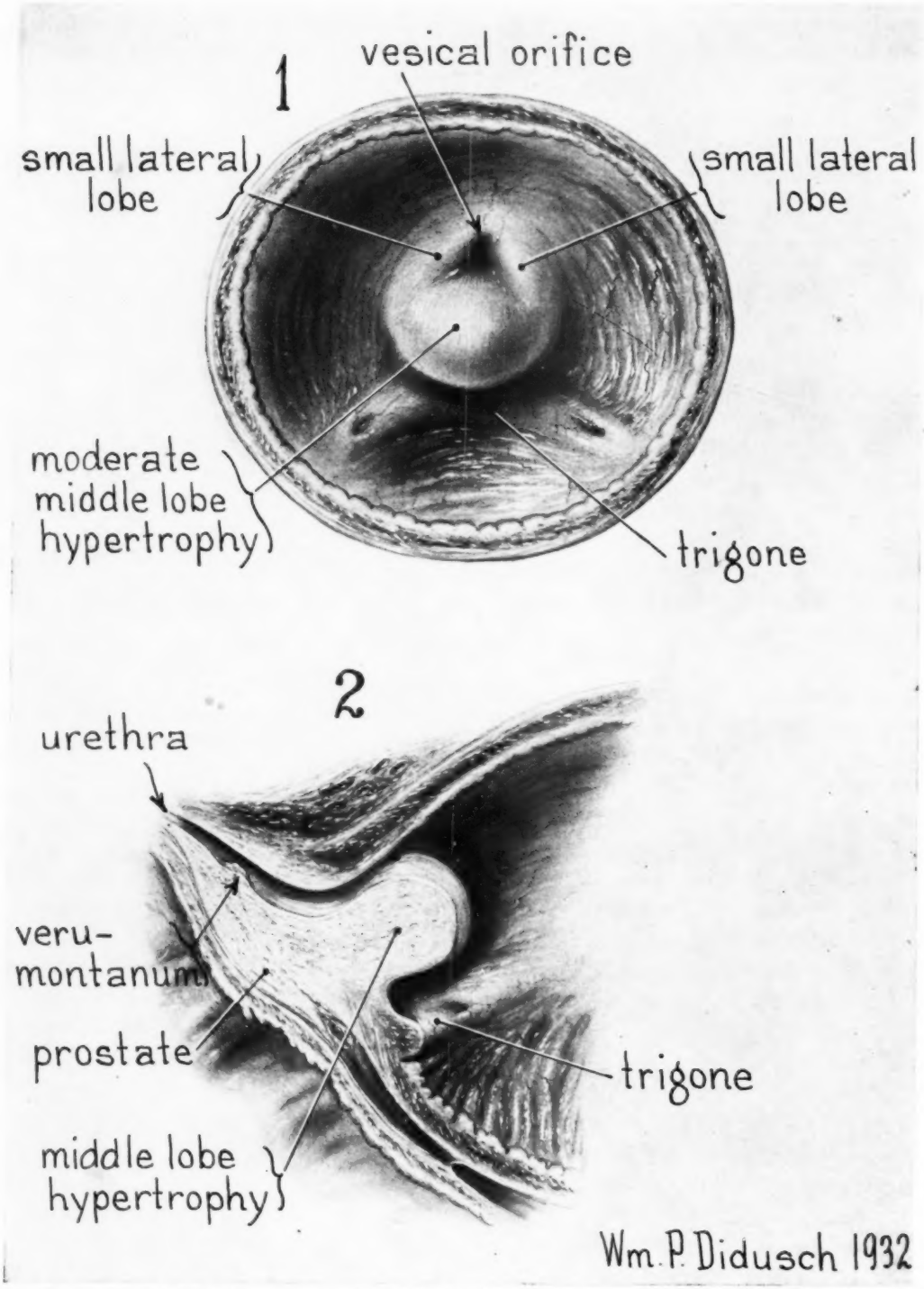

FIG. 12. Typical case suitable for resection. (1) Vesical orifice viewed from within the bladder; lateral lobes but slightly enlarged; middle lobe hypertrophy of moderate degree. (2) Sagittal section at vesical orifice, middle lobe hypertrophy in evidence; verumontanum visible in section.

actual worth can be gauged. The immediate results have been most encouraging. Should this *non-destructive method* prove own which, in my opinion, make it more useful and adaptable to the peculiar needs of vesical neck resection than any which

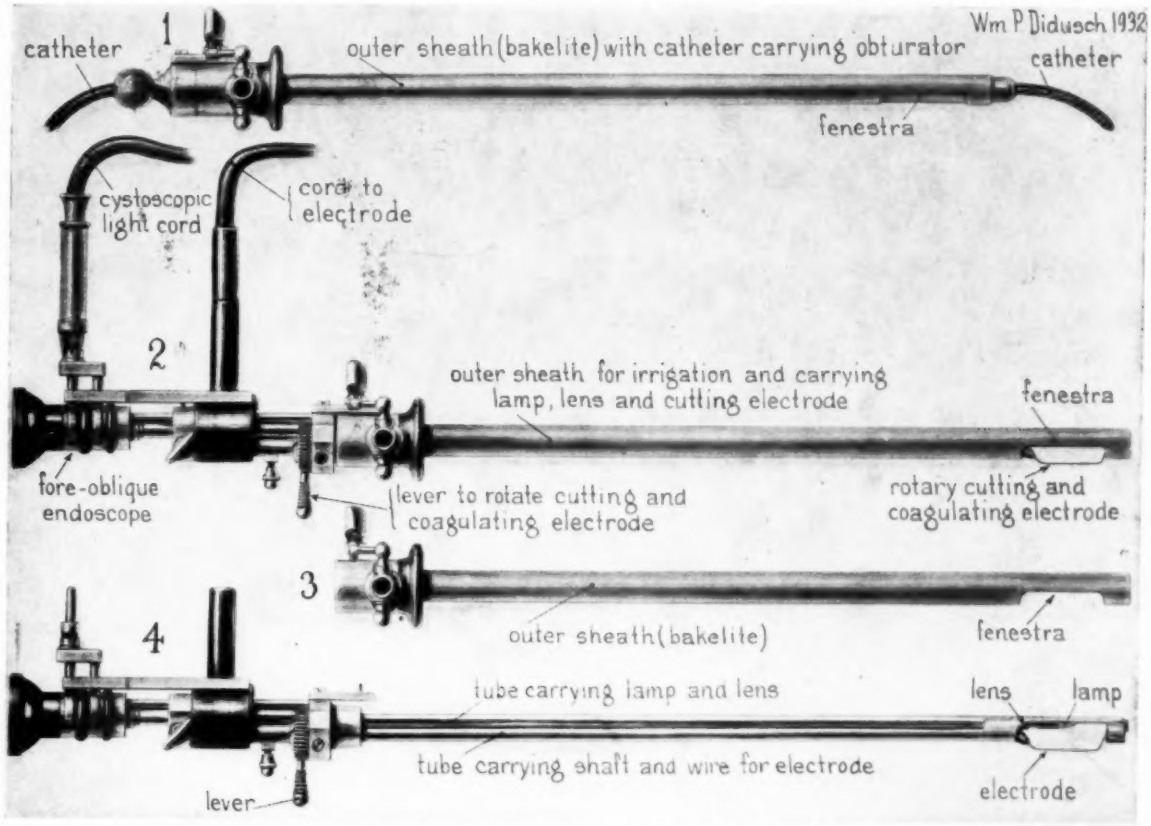

Fig. 13. Kirwin resectoscope. Plate showing instrument. (1) Outer sheath (bakelite) with obturator in place. Note catheter carrying obturator to be used in cases where it is difficult to introduce the instrument. (2) Instrument assembled. Foroblique endoscope; bakelite sheath, carrying lamp, lens, and cutting and coagulating electrode. Electrode consisting of a wire is rotated by means of a lever which is attached to a shaft. (3) Outer sheath showing fenestra. Irrigation is carried out through this shaft and around the tube carrying lens, light and electrode. (4) Foroblique endoscope and tubes carrying lens, light, and cutting and coagulating electrode.

thoroughly practical, it will still further increase the value of electrothermia in the treatment of prostatic and median bar obstruction.

DESCRIPTION OF EQUIPMENT REQUIRED

The instrument I am now using (Fig. 13) is the result of many attempts to attain the requisites to successful radiothermatization which have been set forth in the preceding paragraphs. It embodies features which the gradual accumulation of experience of many operators have added to previously existing patterns, but contains likewise certain additions of my have preceded it. It has an outer sheath of bakelite, and is equipped with an obturator to be used when difficulty is experienced in introducing the instrument. The sheath carries a lamp, a lens and the cutting and coagulating electrode, which is a wire rotated by a lever attached to a shaft. The foroblique telescope designed by McCarthy is so arranged as to permit *complete vision under all conditions wherein the instrument can be employed.* This is a feature of especial importance. Not only is it essential for the operator to see where the obstruction at the vesical neck is located and at just what point the

electrode must be applied in order to secure hemostasis yet not carbonize the tissues; he must also be permitted to view the actual resection, to note every movement of the cutting electrode and the precise situation of every "bite" engaged in the fenestra both before and after it is resected. Though cystoscopy with a right-angle lens system always *precedes* resection in the various devices now available, this feature of continuous observation during the entire procedure offers advantages which hardly need pointing out.

The lever which controls the electrode is attached to a shaft so that it can be rotated in either direction with equal facility. Adapted to the contour of the vesical neck, it leaves behind it a smooth cone-shaped orifice. Details of the electrode are shown in Figure 14. It will be noted in (3) that the wire is directly in the midline and is changing the caliber of the instrument from size 28 to size 32 of the French scale. This permits the use of a sheath several sizes smaller than would otherwise be possible while obtaining so

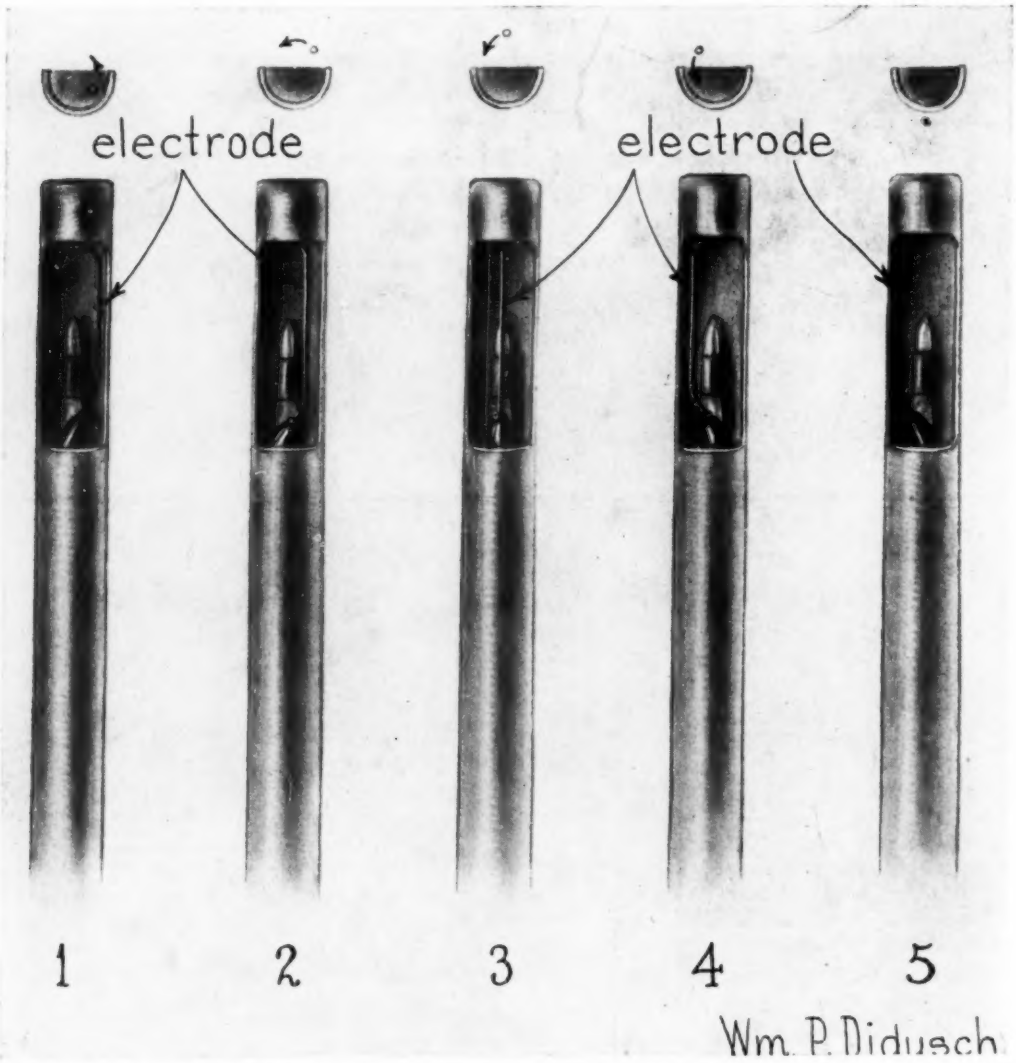

Fig. 14. Detail, showing mechanics of cutting electrode. Instrument as viewed from undersurface, looking into fenestra, and above sectional views of instrument to show position of wire; wire moving from left to right on drawing. Note in (3), wire directly in midline and changing caliber of instrument from 28 F. to 32 F. This enables a larger piece of tissue to be removed.

large a cut, and thus obviates trauma to narrow urethras. The eccentric swing of the wire electrode at its highest point part of both physician and patient that the procedure is to be regarded merely as "minor surgery." Consequently, pre-

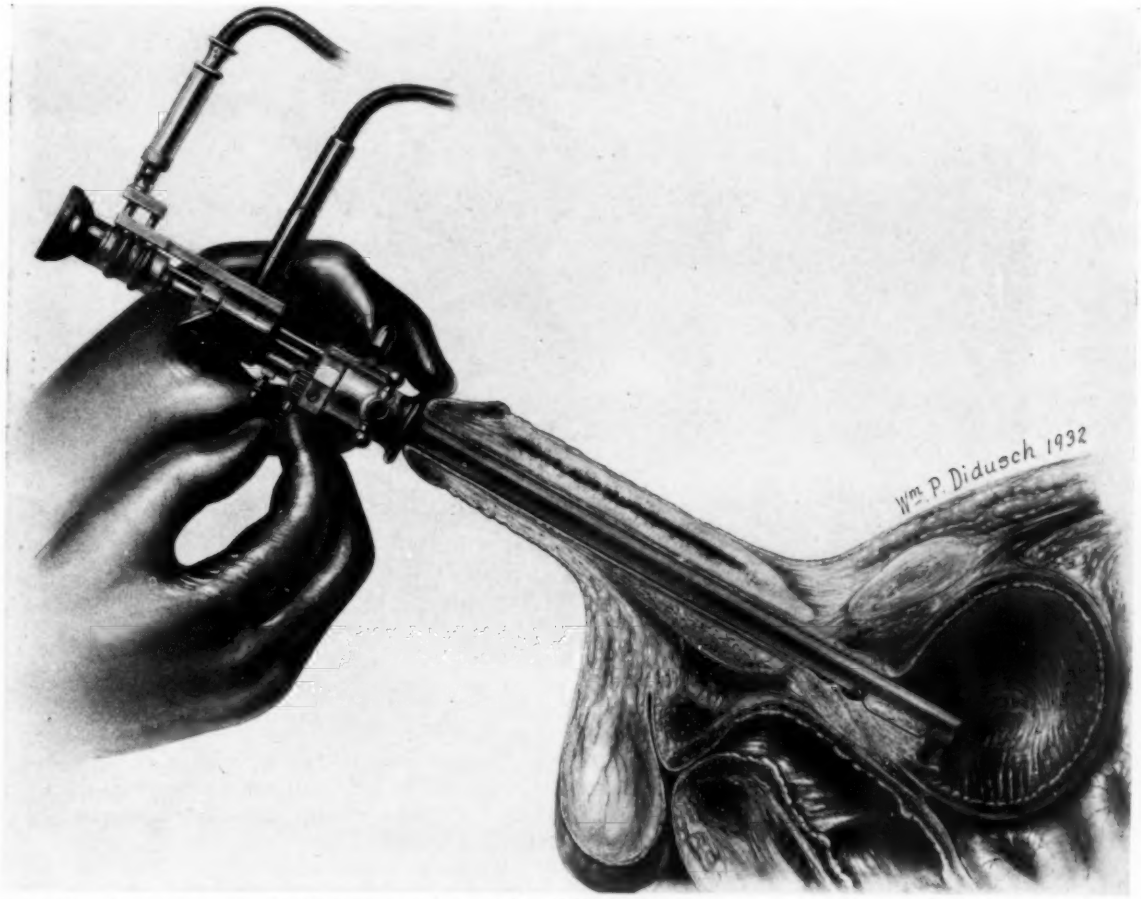

Fig. 15. Sectional view showing instrument in position. Middle lobe has been engaged in fenestra and electrode is removing tissue. Left hand holds instrument in position, shaft being greatly elevated while resection on middle lobe is being carried out. Right hand is grasping lever and slowly rotating it, thereby causing a rotary motion to electrode resecting middle lobe.

exceeds the caliber of the sheath by several sizes, permitting removal of sections of dimensions heretofore obtained only by using instruments so large as to traumatize the urinary canal. This latitude is possible only in a rotary instrument such as this and, as can be seen, greatly increases its usefulness, as well as the scientific precision with which the operation may be carried out.

PREPARATION OF PATIENT

One reason for the many poor results and complete failures which follow intraurethral resection is the feeling on the liminary preparation is neglected and conditions which, if known, would contraindicate the use of this particular therapy are not uncovered until too late.

None of the preliminary measures thought essential for a man about to undergo prostatectomy should be omitted when it has been decided to operate *via* the urethra. Measurement of the amount of residual urine, blood chemistry, urinalysis, and the institution of catheter drainage, if necessary, are just as important now as in open operation. Some operators even recommend suprapubic drainage in extreme cases, but in my opinion, if

conditions are such as to demand gradual decompression or suprapubic cystotomy, residual urine being so large in amount

is established. Between these two structures lies the field of resection, and the avoidance of injury to either of them is one of the

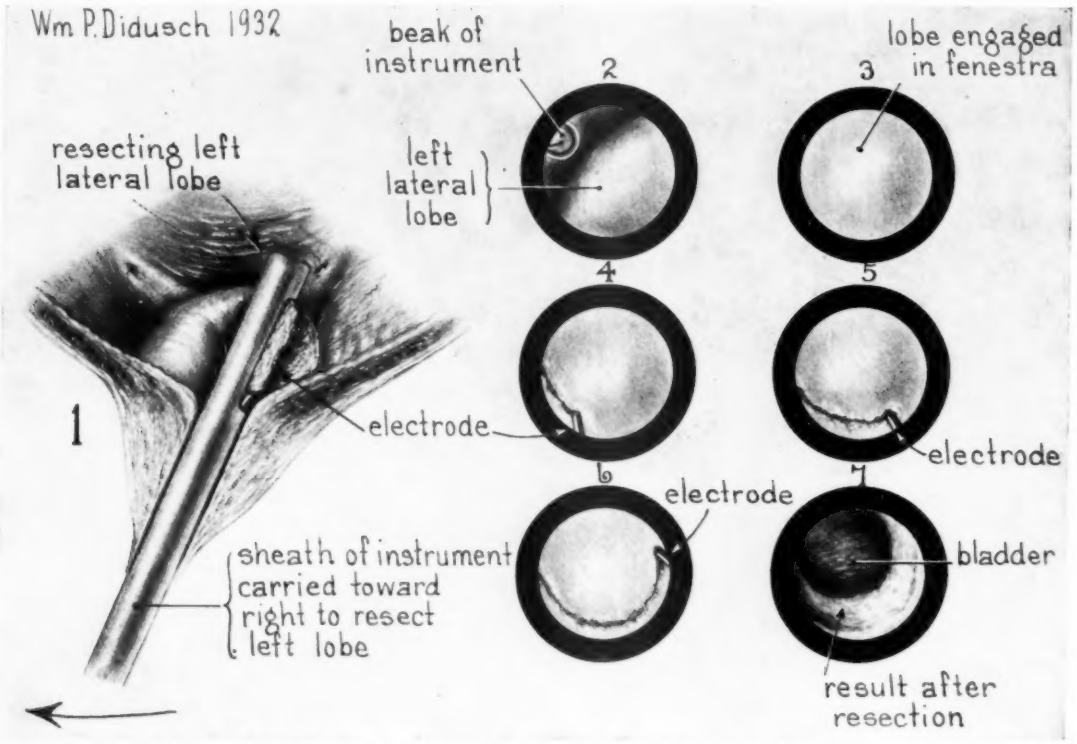

Fig. 16. Resecting left lateral lobe: (1) View of bladder and vesical orifice. Shaft of instrument carried well to right side of patient while resecting left side of vesical orifice. Wire electrode can be seen removing a portion of left lateral lobe. (2) Cystoscopic view of resection carried out on left side. Left lobe of prostate and beak of instrument. (3) Lobe engaged in fenestra and now in position to resect. Note that beak of instrument cannot be seen. (4) Electrode beginning to cut through prostatic tissue (beginning of arc) from left to right. (5) Further movement of electrode through tissue. (6) Electrode about to complete cut. (7) Result after cut has been made. Shows bladder and a large groove through prostate.

and intrusion of the lateral lobes sufficient to make such drainage imperative, the case is distinctly unsuited for intraurethral methods.

TECHNIQUE

The procedure as carried out in different degrees of prostatic hypertrophy is depicted in Figures 15, 16, 17 and 18. The diagnosis made and the patient properly placed upon the table, the instrument is inserted and the field of resection oriented. The ureteral orifices are first located and the center of the interureteric ridge, midway between them, ascertained. By withdrawing the instrument somewhat, the precise position of the verumontanum

chief technical points in the entire procedure.

When all three lobes are enlarged intervention should be first upon one lateral lobe, either right or left. If, as some operators advise, the middle lobe be first attacked, its removal will cause the two lateral lobes to collapse toward each other, with resulting difficulty in the control of bleeding and the efficient removal of the remaining tissue. If the left lateral lobe be first resected, the shaft of the instrument is carried well to the patient's right side, thus forcing the tissue into the fenestra as shown in Figure 16(3). When this is accomplished the beak of the instrument is no longer within the visual range, indi-

cating that the lobe is in position to be resected. The cutting arc passes from left to right as shown in Figure 16(4). The tissue which must be taken out in order to open such a passageway depends not alone on the size of the middle lobe, but even

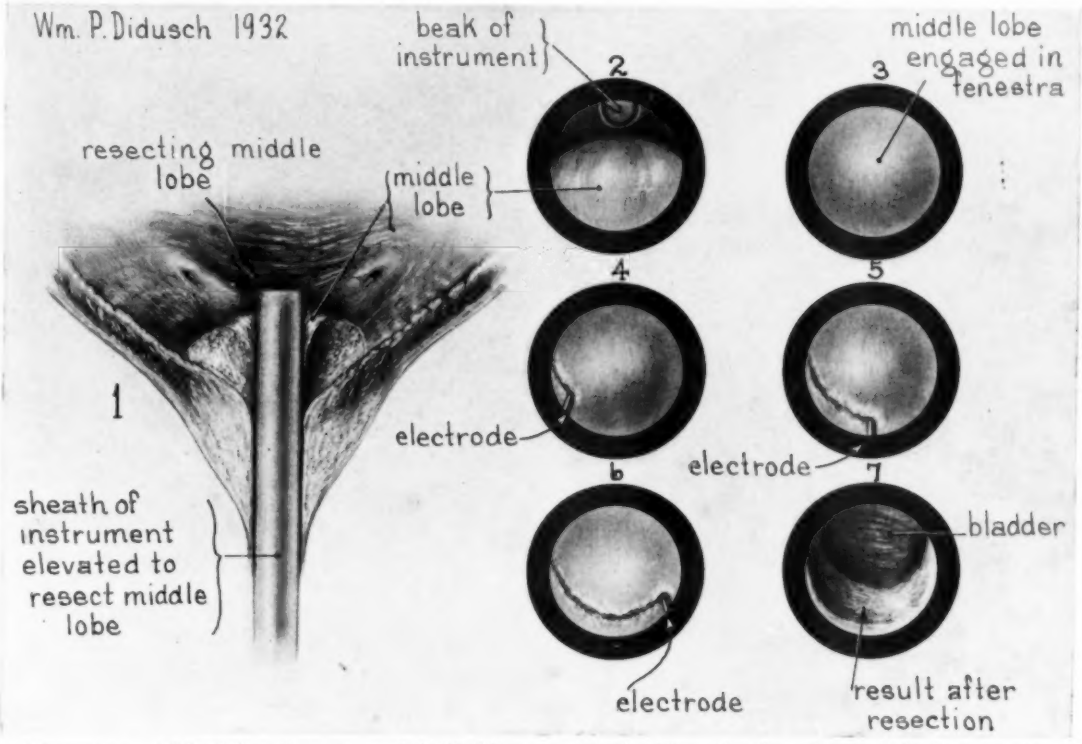

Fig. 17. Resecting middle lobe of prostate. (1) Bladder at vesical orifice. Cutting electrode is downward and cannot be seen. In resection of posterior or middle portion of vesical orifice, shaft of instrument must be greatly elevated in order to engage tissue in the fenestra. (2) Cystoscopic view of resection carried out on middle lobe. Shows middle lobe and beak of instrument. (3) Lobe engaged in fenestra and now ready to be resected. Note that beak of instrument cannot be seen, proving that lobe is well within fenestra. (4) Electrode beginning to cut through prostatic tissue (beginning of arc) from left to right. (5) Further progress of electrode through tissue. (6) Electrode about to complete cut. (7) Result after a cut has been made. Shows bladder and a large groove through prostate.

cut completed, the obturator carrying the cutting electrode is unlocked, rotated and withdrawn, bringing with it the cut piece of tissue. In this way a field clear of debris is insured and visual evidence of the amount of tissue so far resected is constantly in view.

EXTENT OF RESECTION

Every surgeon investigating this technique has asked: How do you know when enough tissue has been removed? My answer is: When you can see an unobstructed passageway from the verumontanum to the interureteric ridge. The amount of more upon the amount of lateral lobe intrusion. The tendency of those unfamiliar with the McCarthy foroblique lens system is to take out too much. A right angle lens, coming in almost immediate contact with the object to be viewed makes this appear larger than natural size. In his mind's eye the examiner makes allowance for this distortion. With the McCarthy foroblique lens system, within a range varying from a quarter to a half an inch the object viewed will continue to appear its actual size. Therefore, it is easy, when changing from the right angle lens used in the preliminary examination to the different type employed for the actual resection, to continue making

mental allowance for an exaggeration in size, and deem it necessary to make a far larger resection than the case requires.

sure upon the perineum by packing, evacuate the clots through a large catheter, and wash out the bladder with silver

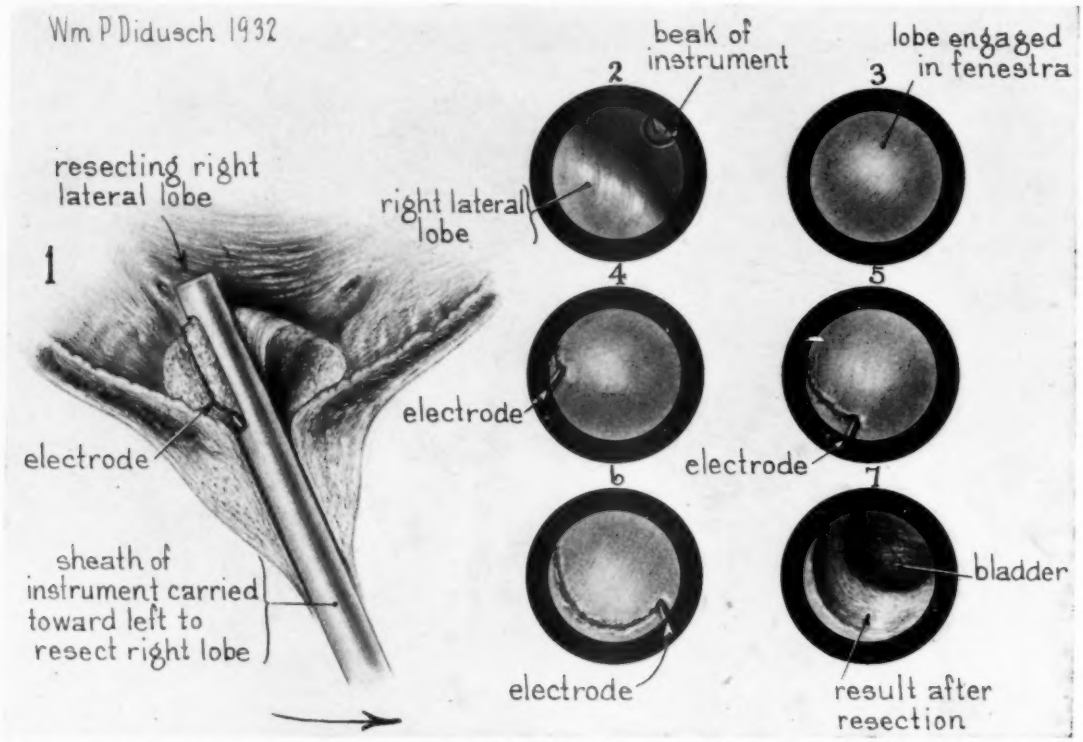

Fig. 18. Resecting right lateral lobe. (1) A view of bladder and vesical orifice. Shows shaft of instrument carried well to left side of patient while resecting right side of vesical orifice. Wire electrode can be seen removing a portion of right lateral lobe. (2) Cystoscopic view of resection carried out on right side. Right lateral lobe and beak of instrument. (3) Lobe engaged in fenestra and now in position to resect. Note that beak of instrument cannot be seen, proving that lobe is well within fenestra. (4) Electrode beginning to cut through prostatic tissue (beginning of arc) from left to right. (5) Further movement of electrode through tissue. (6) Electrode about to complete cut. (7) Result after a cut has been made. Shows bladder and a large groove through prostate.

AFTER-TREATMENT; COMPLICATIONS; REMOTE RESULTS

The resection completed, I regularly introduce a whistle-tipped cathether without any stylet. I do not pass a catheter before removing the instrument, for any small enough to go through it would be too small to exert enough pressure to stop hemorrhage should this occur postoperatively. In a few cases where, because of great edema of surrounding tissue, I could not use the whistle-tip, I resorted to a wing-tipped catheter with stylet, which will enter even in the presence of much edema.

If, despite every care, postoperative hemorrhage does take place, I exert pressure upon the perineum by packing, evacuate the clots through a large catheter, and wash out the bladder with silver nitrate 1:5000. In a few instances we have had to resort to suprapubic cystotomy in order to do this.

Retention of urine after resection has given trouble in 3 of a series of about 80 cases. For three, four and five weeks respectively, these men were unable to urinate. All had had large resections, the amount of obstructing tissue present being greater than can properly be removed by the intraurethral route. One had had the hemorrhage demanding suprapubic cystotomy and packing. Fortunately, none of these cases terminated fatally. There were, however, three deaths in the series. One man died from cerebral hemorrhage, which may or may not have been referable to the intraurethral intervention. A second succumbed

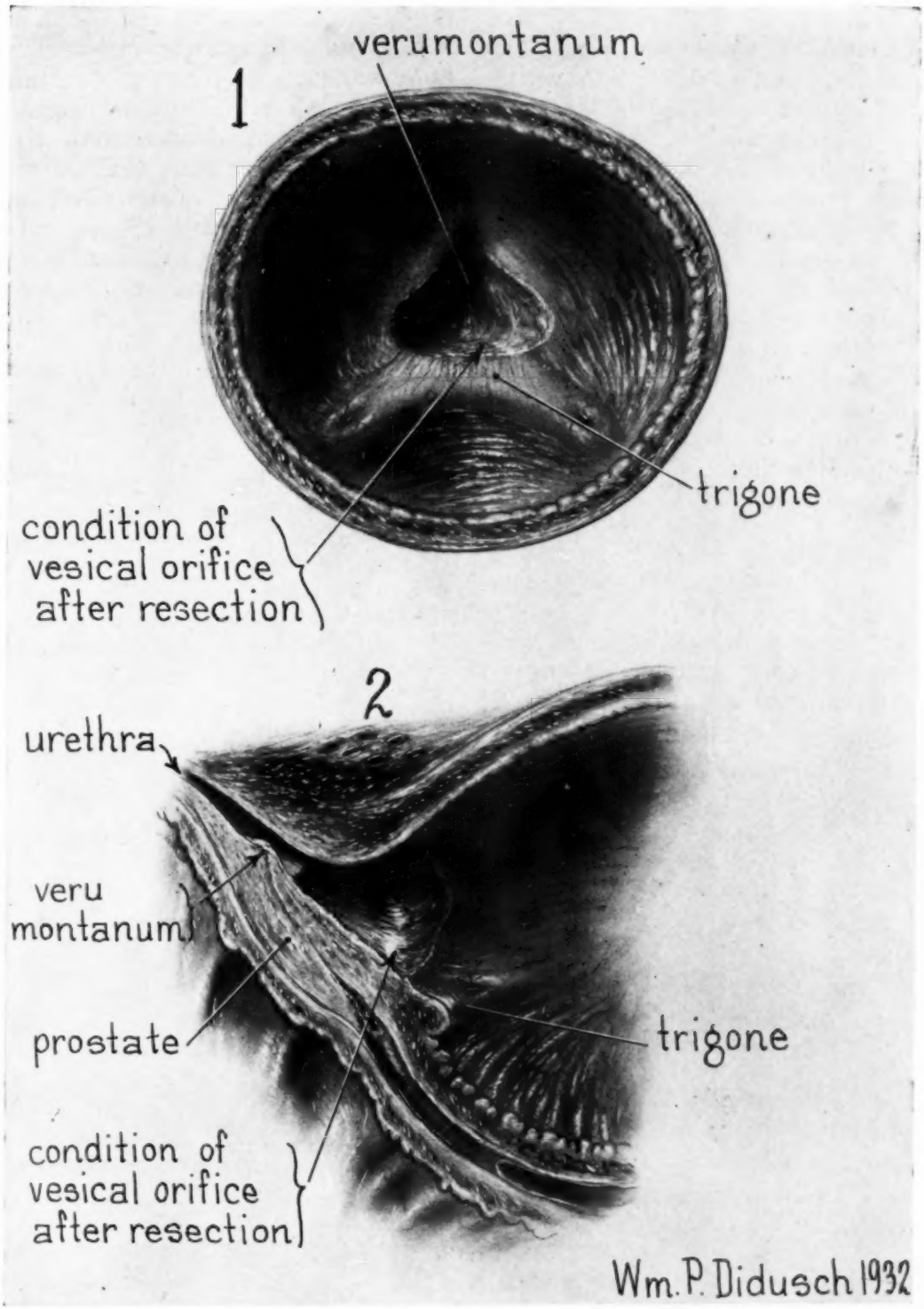

FIG. 19. Result after resection: (1) Vesical orifice as viewed from within bladder. Note cavity from which hypertrophied tissues have been removed. Veru-montanum can be seen within urethra, and resection carried downward on trigone but not injuring interureteric ridge. (2) Sagittal section shows results after resection of hypertrophied tissue. Note cavity at vesical orifice and extending about 1 cm. posterior to verumontanum and well out on trigone.

to the myocarditis, on account of which prostatectomy had been contraindicated. The third developed a rapidly fatal peritonitis, and at postmortem examination a rent was discovered in the posterior urethra, causing all bleeding and discharge to become retroperitoneal, none passing by way of the urethra.

The first death could not have been avoided by any preoperative precaution; in the second case the "chance" which we took fell against us; the third was probably chargeable to too large a resection, though it should be mentioned that all three of these patients were of the "last resort" class, with but a short time to live under any circumstances.

CONCLUSION

The application of high-frequency current to vesical neck resection has passed from empiricism to scientific precision in the design of armament and the standardization of technique. It remains empiric however, when the control of hemorrhage is undertaken with a spark-gap generator, dependent upon condensation of the tissue into an indurated mass with obliteration of the individual vessels. To seal the individual vessels with the proper current strength generated by a radio-tube machine is the equivalent of good surgical technique in the performance of the open operation.

In closing I would make acknowledgment of the aid which alone has made possible the work just outlined. My chief, Dr. Oswald Swinney Lowsley, has placed at my disposal abundant clinical material, and with his staff, afforded me continual cooperation and encouragement. Mr. Reinhold Wappler and his son, Mr. Frederick C. Wappler, gave concrete form to my ideas and assisted me in a thousand details. The beautiful illustrations of Mr. William P. Didusch speak for themselves. To all these friends and willing co-workers I would offer most appreciative thanks.

PREFIBROSIS AT THE VESICAL NECK

ITS PATHOLOGICAL STATUS AND CLINICAL SIGNIFICANCE*

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THE role of the prostate in infections at the vesical neck and posterior urethra has long been recognized. Interpretations of the degree of involvement by urethroscopy, examination of the secretion and digital palpation have been properly evaluated. The inflammatory changes of these structures, due to their intimate relationship, has been understood, but sufficient consideration has not been given to their influence on the submucosal group of glands located at the prostatic urethra, vesical neck and trigone. Their response to repeated infection from the prostate and seminal tubules or from the upper urinary tract is a potential factor in median bar formation.

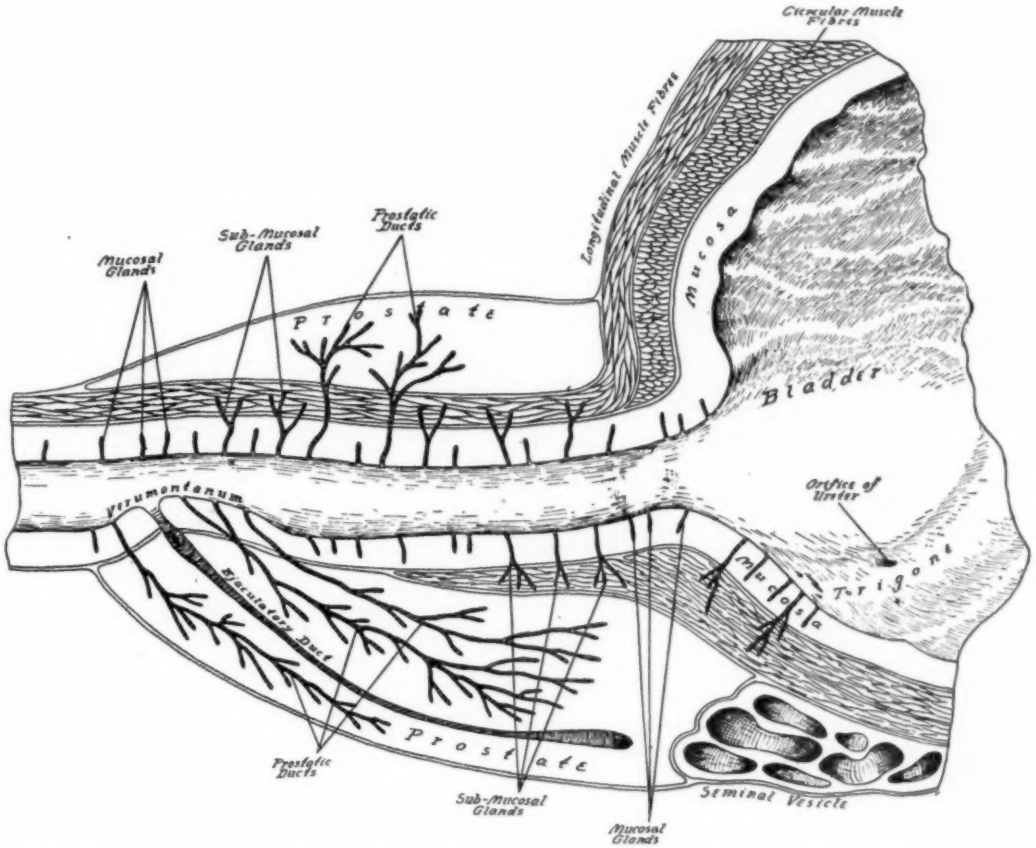

FIG. 1. Schematic representation of posterior urethra and vesical neck, showing distribution of prostatic and accessory (mucosal and submucosal) glands.

In addition to the major prostatic gland groups comprising the posterior and lateral lobes and posterior commissural glands, an accessory group of superficial glands are found in the prostatic urethra, vesical

* Read before the Section of Genito-Urinary Surgery, New York Academy of Medicine, Nov. 18, 1931. From the Department of Urology, N. Y. Post-Graduate Medical School and Hospital, Columbia University.

neck and trigone (Fig. 1). Unlike the compound racemose character of the deeper prostatic structures, these glands are frequently rudimentary or absent. When present, they extend for varying distances into the mucosa, submucosa and occasionally into the muscularis. In the posterior urethra, they predominate on the sides and roof; on the vesical neck and trigone, they are limited to the central portion of the posterior vesical lip. Although they have been given a variety of names, they are homologues of the prostatic glands. Their close anatomic and functional association with the true prostatic glands explains the interrelation between inflammatory pathologic processes in the prostate and vesical neck. In addition to giving rise to the pseudo-hypertrophies of the accessory groups, they undergo infection concomitant with the prostatic and seminal tracts, and are an essential feature in bladder neck and trigonal involvement complicating posterior urethritis.

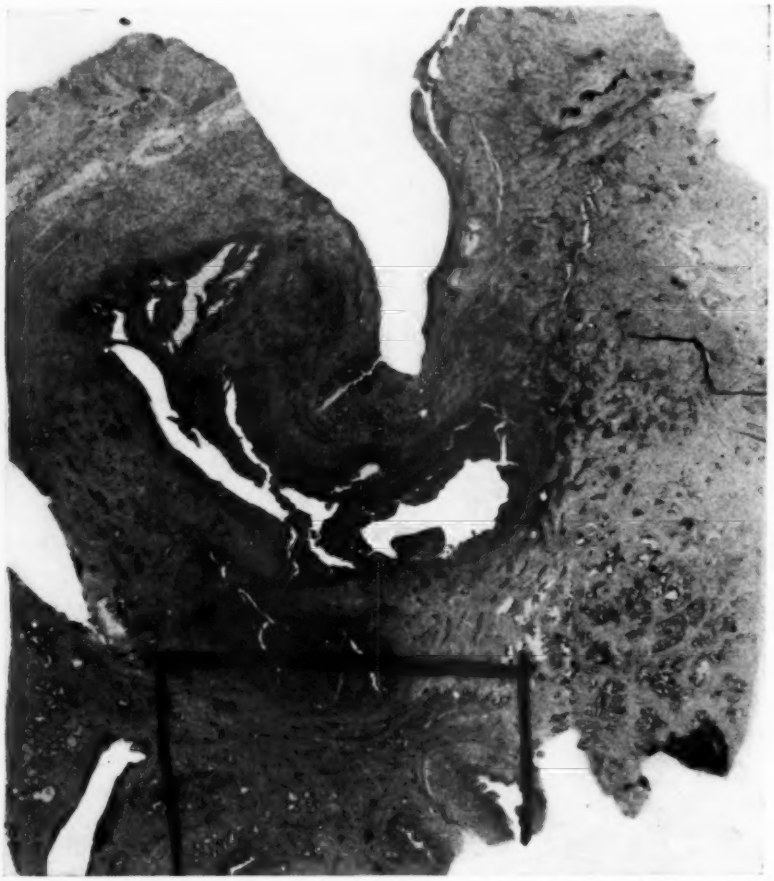

FIG. 2. Large transverse section (low magnification) of vesical neck region in specimen showing prostatic abscess. Submucosal glands on vesical neck and trigone showed acute inflammatory involvement corresponding to that seen in prostatic and seminal tracts.

Infection of this submucosal group of glands causes changes at the vesical neck and posterior urethra, which because of their particular situation, may eventuate in obstructive pathology at these sites. The progressive stages of this inflammatory process have been demonstrated in our histopathological study of necropsy material and observations in hundreds of clinical cases, many of which have been followed for several years.

The term prefibrotic bar has been applied to the inflammatory elevation

at the vesicourethral orifice, retromontane and glandular adnexa, engendered by infection of the submucosal glands. Continued infection of these structures, in many instances, terminates in a fibrous median bar with vesical neck coarctation or scirrhous changes in the posterior urethra.

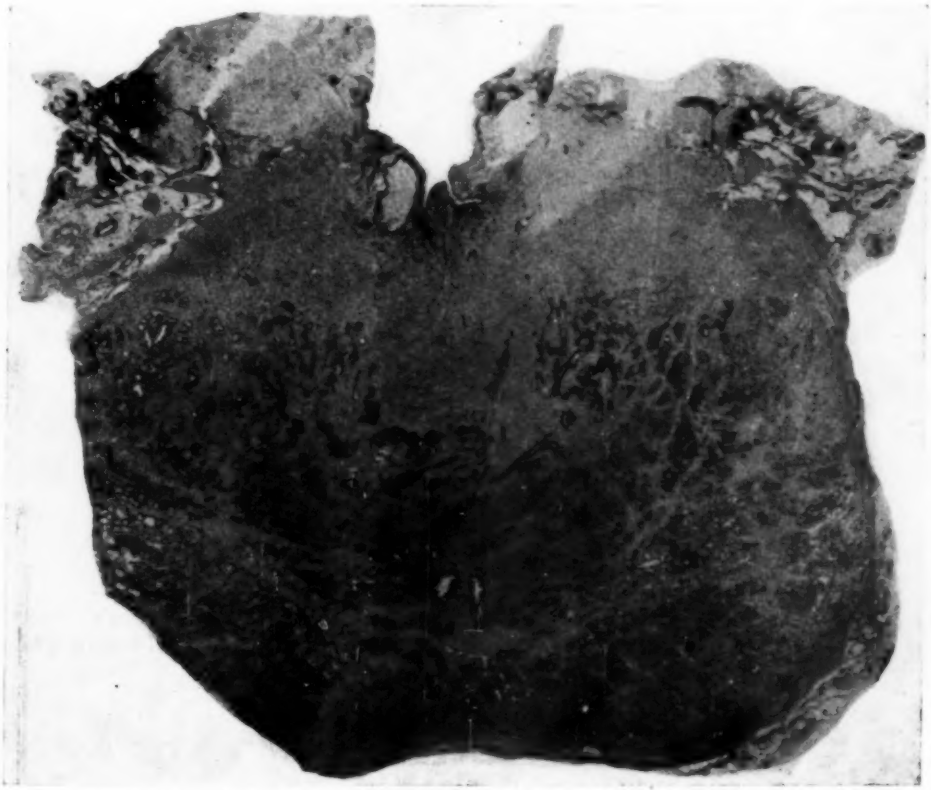

Fig. 3. Large transverse section (low magnification) through region of vesical neck in specimen demonstrating prefibrotic elevation of posterior vesical lip. Note chronic inflammation of submucosal gland group with cystic dilatation. Prostate shows corresponding chronic inflammation.

When infection is disseminated through the prostate gland, its persistence is manifest and repeated infection of the prostatic urethra takes place, due to evacuation of the contaminated secretion which bathes the orifices of the mucosal glands in its outward course.

Due to the close anatomical relationship of the ejaculatory and prostatic duct openings with those of the submucosal glands when present, they share in the initial surface infection or mechanical irritation. The ejaculatory ducts participate by contiguity in the infection to the same extent as the prostatic tissue. The persistence of infection in the seminal tubule is an added factor in maintaining reinfection of the submucosal glands. This close association must be borne in mind continually.

A thorough gross and histological study of the region lying between the interureteric ligament and the ejaculatory duct was undertaken, in an attempt to determine the etiology and pathogenesis of obstructive vesical neck fibrosis. It soon became evident that no comprehensive study of the vesical neck was possible without a coordinated microscopic study of all the adnexa. This led to a gross and microscopic study of the seminal vesicles, ejaculatory ducts, verumontanum and prostate, as related to the visible and tactile gross evidences of inflammation in the periprostatic and perivesicular tissues, prostatic urethra and vesical neck.

By a study, gross and microscopic, of a large group of specimens demonstrating all stages of prostatic inflammation, and with indefinite gross evidences of prostatic or seminal vesicular inflammation.

3. Those specimens which showed

FIG. 4. Large sagittal section (low magnification) through posterior vesical lip and floor of prostatic urethra, showing prefibrotic elevation of posterior vesical lip. Note group of submucosal glands situated on posterior vesical lip. Chronic inflammatory changes are seen in seminal vesicle, ejaculatory duct, verumontanum, prostatic and submucosal gland groups.

the coordination of these findings with visible distortion, elevation and constriction of the vesical neck and posterior urethra, a better composite picture was obtained of the inflammatory reactions of the entire adnexal and vesical neck regions and their etiological relationship to one another.

Eighty-four selected specimens were subjected to serial microscopic study of the region between the verumontanum and the interureteric ligament, made sagittally and transversely, of sufficient size to include all the adnexa in their normal relation to the prostatic urethra and vesical neck.

This material fell into the following groups:

1. Those specimens that showed active suppurative lesions of the prostate, or periprostatic and vesicular regions.

2. Those specimens which showed gross manifestations of active, acute or subacute urethral and bladder neck inflammation, cicatricial changes of the vesical neck, prostatic urethra, with patent dilated prostatic ducts, cribriform deformity of the prostatic urethra and distortion of the verumontanum. Gross evidences of vesicular induration and infiltration were indefinite and difficult to interpret.

4. Those cases which showed little changes in the prostatic urethra, with chronic inflammatory lesions of the upper urinary tract.

In addition, 60 selected specimens were subjected to gross study of the seminal vesicle, ampulla and ejaculatory ducts by means of celloidin corrosion casts and the findings in these casts were coordinated with gross studies of the prostatic urethra and vesical neck, together with non-serial microscopic examination of the prostate and non-injected vesicle. Gross studies of many hundreds of necropsy specimens and the coordinated microscopic examinations definitely convinced us that inflammatory distortions of the vesical neck,

prostatic ducts and verumontanum gave a better indication as to the incidence of low grade chronic inflammation in the prostatic and seminal tracts than could be obtained by palpation of the seminal vesicles and prostate alone. In all stages of prostatic and seminal tract inflammation the posterior urethra and vesical neck showed gross changes which were characteristic. Tissue removed from the posterior vesical lip with the McCarthy punch in proven cases of median bar were studied microscopically and comparisons were made with necropsy material demonstrating similar vesical neck deformity. It was thus possible to visualize the deep seated changes in the adnexa of necropsy specimens in which the vesical neck findings corresponded to the clinically proven median bar tissue obtained with the punch.

Microscopic study of 62 specimens revealing acute, subacute and chronic prostatitis showed corresponding inflammatory changes on the posterior vesical neck. Our studies revealed this to be due to the distribution of the accessory gland structures on the posterior vesical lip and trigone, and the involvement of these glands together with the prostate and at least the juxtaurethral portion of the seminal tract, is an essential feature of the inflammatory reactions of the posterior vesical lip, in the subacute and chronic stages preceding bar formation. It was found that the inflammatory changes in the vesical neck structures were always accompanied by involvement of the prostate corresponding exactly in stage, severity and degree to the former. However, the seminal tract in its deeper portions showed corresponding involvement in only about 20 per cent of these specimens. An additional 30 per cent showed definite inflammatory change in the verumontanum and ejaculatory ducts with only slight changes in the seminal vesicles.

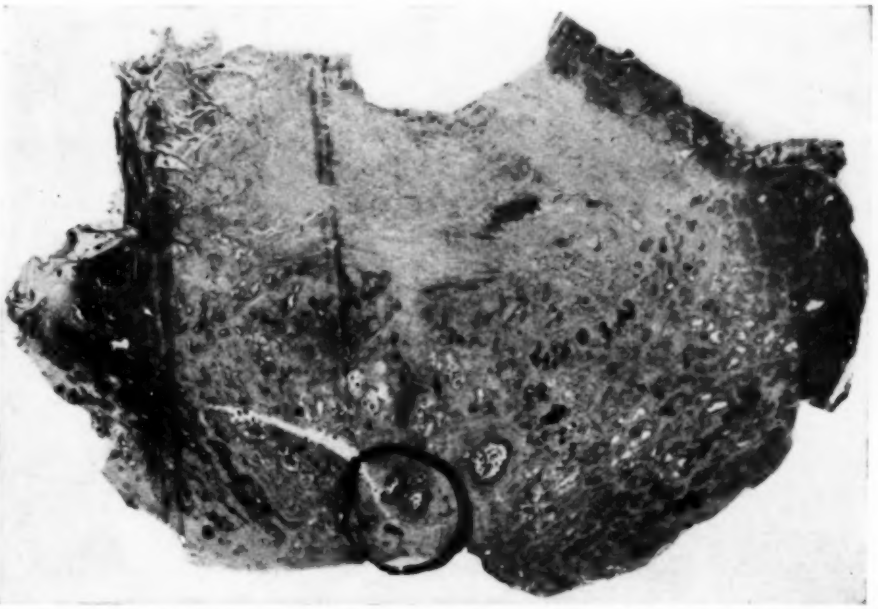

Fig. 5. Large transverse section through region of vesical neck in specimen revealing terminal vesical neck fibrosis. Note submucosal glands compressed by fibrous tissue replacing sphincter muscle. Prostatic and seminal tracts demonstrate low grade inflammatory changes.

It appears evident from these studies that the accessory gland involvements which cause vesical neck deformity always occur concomitantly with prostatitis and a consideration of all stages of prostatitis, and coincident gross and microscopic

involvement of the vesical neck, must give a true conception of the etiology and pathogenesis of vesical neck fibrosis.

FIG. 6. Earliest phase of prefibrosis: a general dissemination of infection, beginning elevation of posterior vesical lip, acute and subacute inflammatory changes in posterior urethra and subjacent glandular structures.

Thus, studies of the entire region during the stages of acute, subacute and chronic inflammation with vesical neck elevations and deformities have enabled us to evaluate the role of the inflamed prostate in the production of prefibrotic and fibrotic vesical neck distortions.

The term, acute inflammatory or prefibrotic bar, has been given to the vesical neck deformity and elevation accompanying acute and subacute inflammation of the entire region. Demonstration of the initial lesion and its subsequent development has clearly shown the etiological relationship between vesical neck fibrosis and prostatitis.

Acute posterior urethritis and prostatitis were frequently accompanied by irregularity of the posterior vesical lip, which presented a nodular edematous appearance with an engorged, rounded elevation of the waterfall and trigone. In these specimens the submucosa of the vesical neck was infiltrated with polymorphonuclear leucocytes and plasma cells. The submucosal and mucosal glands (accessory glands) of

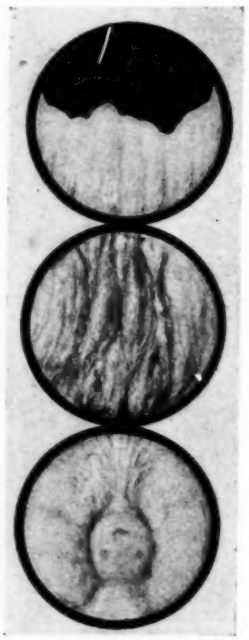

FIG. 7. Subacute stage: early hyperplastic elevation of sphincter floor, bulging edema of retromontane, mucopurulent material exuding from duct openings, mirroring inflammation in prostate and ejaculatory ducts.

the trigone and vesical neck were distended with cellular exudate and desquamated epithelium. The submucosa of the posterior urethra showed marked infiltration with polymorphonuclear and plasma cells. The prostate demonstrated corresponding intra-acinous and peri-acinous cellular exudate with infiltration of the stroma by polymorphonuclear leucocytes and plasma cells. In some specimens, large destructive suppurative foci were noted (prostatic abscess) and in others, small follicular areas of suppuration were found (Fig. 2). Involvement of the seminal tract corresponded in degree and severity with that found in the prostate, vesical neck and prostatic urethra.

Vesical neck deformity demonstrating bar-like elevation of the posterior vesical lip was seen with a histological picture of subacute and active chronic inflammation of the prostate, vesical neck and seminal

tract. Because the stage of inflammation was not of the terminal fibrous type, the name prefibrotic bar was given to this deformity. Shortening of the retromontane urethra, cribriform deformity about the verumontanum, distortion of the size, shape and position of the verumontanum, and dilated prostatic ducts, gave unmistakable gross evidence of chronic posterior urethral and prostatic inflammation. The submucosal glands of the posterior vesical lip and prostatic urethra showed cystic dilatation, intra-acinous and peri-acinous round cell infiltration and newly formed fibrous tissue replacing the supporting sphincter muscle (Fig. 3). The prostate revealed active chronic inflammation with similar cellular exudate within and around its acini, and corresponding fibrous involvement and round cell infiltration of the stroma. The seminal tract, frequently in its juxtaurethral portion, showed corresponding chronic, low grade inflammatory involvement (Fig. 4).

The terminal stage, with fibrotic elevation and coarctation of the vesical neck, demonstrated cicatrization of the vesical neck and sphincter, with compression of the accessory gland structures and very little microscopic evidence of active inflammation of the affected parts (Fig. 5). The microscopic picture within the prostate demonstrated unmistakable evidences of chronic inflammation corresponding in stage to that found at the vesical neck.

From this, it is evident that the vesical neck deformities which eventuate in fibrotic obstruction are a part of the composite picture of inflammation of the prostate and other adnexa of the posterior urethra and vesical neck. Because of their complexity and their anatomic relationship to the urinary outlet, the inflammatory involvements of the prostatic and accessory gland structures assume particular importance as a cause of vesical neck obstruction.

It is apparent that only correlated clinical and pathological study of these intimately related structures permit interpretations of vesical neck, prostatic and urethral changes, impossible with the ordinary cystourethroscopic technique or other routine investigations.

Fig. 8. Fig. 9.

Fig. 8. Prefibrosis: hyperplastic elevation at posterior vesical lip and sphincter, excavation of retromontane, duct openings patulous.

Fig. 9. Fibrous median bar with angulation at either side, late chronic inflammatory change in posterior urethra and subjacent glandular adnexa.

Patients who showed clinical evidence of prefibrotic elevations almost invariably complained of some type of urinary disturbance. These cases could be classified as follows:

1. Acute inflammatory changes at the vesical neck and posterior urethra
2. Subacute inflammation at the vesical neck and posterior urethra with subacute prostatitis: early prefibrotic elevations
3. Prefibrotic elevations: inflammatory median bar, scirrhous changes in the retromontane area and evidence of chronic inflammation in the prostatic and ejaculatory ducts, and chronic prostatitis.

The changes during the acute stage can be deduced from the pathology found in the necropsy specimens and occasional cystourethroscopic observations in the

living. In this stage, some or all of the following clinical findings are noted: acute prostatitis, active acute catarrhal inflammation of the posterior urethra and vesical neck with engorgement and edema of the mucosa (Fig. 6). The ejaculatory and prostatic ducts show acute inflammatory changes. Similar changes are observed at the verumontanum and retromontane space with elevation at the site of the subcervical glands. Whether the process goes on to acute suppuration or subsides to the chronic stage, the pathology in the posterior urethra must be viewed as being a phase of the generalized infection. The earliest phase of prefibrosis is found to accompany infection of the posterior urethra, while with continued re-infection or mechanical irritation, the subacute stage of prefibrotic obstruction ensues.

In the subacute stage, some of the acute symptoms have subsided. Fever disappears. Pain, dysuria and difficult urination may be present, but are less marked. There is no residual urine. Products of inflammation are seen in the urine and in the prostatovesicular secretions. On inspection, the posterior urethra shows moderate evidence of inflammation. Infection of the seminal tract, which frequently accompanies this phase of activity, is an added factor in the pathology present. On cystourethroscopic examination, there may be evidence of the dissemination of the infection throughout the glandular structures of the posterior urethra. The sphincter is edematous with hyperplastic change in varying degree over its entire circumference and elevation of the floor. The retromontane area is bulging or vertical with surface edema. The prostatic duct openings are evident. Frequently plumes of mucopurulent material are seen exuding therefrom. There may be edema or engorgement of the verumontanum with visible ejaculatory duct openings. These changes present at the vesical neck can be interpreted as a phase of early prefibrotic elevation which will resolve, remain stationary, or, with continued re-infection from the upper urinary tract or subjacent glandular structures, eventuate in the later phase of prefibrotic elevation (Fig. 7).

Prefibrosis is accompanied by active chronic prostatitis or continued infection or trauma from the bladder or upper urinary tract. A review of our clinical material showed that infection of the ejaculatory ducts and vesiculitis of a low grade was almost invariably found associated with it. The degree and extent of the process was determined by bimanual rectal examination, examination of the prostatovesicular secretions obtained by the method of Von Lackum, a penis clip being used to retain the secretion expressed for microscopic examination in the urethra during massage of the prostate and seminal vesicles. The McCarthy cystourethroscope and panendoscope were used for examination of the bladder, vesical neck and prostatic urethra to determine the pathology present. The cystourethroscopic changes were in direct proportion to the surface reaction and to the amount of active inflammation in the contiguous glandular structures, so clearly demonstrated in the pathological study.

Our observations, both pathological and clinical, have been sufficiently extensive to enable us to formulate the following description. There is discomfort or spasm at the internal sphincter on introduction of the instrument which is more frequent than in those patients with fibrotic median bar. The sphincter floor does not show a dense smooth fibrous transverse elevation of the posterior vesical lip, but an irregular ridge of distinctly hyperplastic tissue. Its crest is broad and engorged and forms a slight angle with the lateral sphincter walls on either side. It is frequently surmounted by edema of a cystic type or a more diffuse cobble stone appearance, while often, large flattened or pedunculated polyps are observed. Hyperplastic change is frequent on the vault and sides of the sphincter. The retromontane area is vertical or bulging, the mucosa engorged

and thrown into vertical folds, while in other instances, it is excavated with its surface distorted. Numerous dilated prostatic ducts are often seen presenting a cribriform appearance from which mucopurulent material exudes. The verumontanum is enlarged and distorted, shows surface edema, with the ejaculatory duct openings patulous in most instances, reflecting the presence of active inflammation in the prostate, ejaculatory ducts and seminal vesicles. The trigone may be elevated or depressed. Bas fond, trabeculation and hypertrophy of the trigone are not marked or absent in the prefibrotic stage. A moderate degree of intraurethral encroachment of one or both lateral prostatic lobes is frequently seen with surface inflammation.

Table 1 shows a comparison of cystourethroscopic findings in prefibrosis and fibrous median bar:

Table 1

	Prefibrosis	Median Bar
Residual urine.....	None, or small amount	Constant, greater amount
Trabeculation.....	Slight	Marked; cellules; diverticulum
Bas fonde	Slight	Marked; invariably present
Trigone.....	Surface edema, elevation or depression	Hypertrophy; elevation or depression
Vesical neck.....	Spasm, slight obstruction; inflammatory elevation; broad ridge; engorgement; slight bilateral angulation; cystic edema; polyps	Obstruction; fibrotic bar, thin to dense fold; bilateral angulation
Sphincter.....	Hyperplastic change; edema; cysts	Scirrhous; coarctation
Retromontane area	Engorged; vertical bulging, or excavated distortion	Shortened; engorged, vertical bulging or excavated distortion
Prostate.....	Slight bilateral encroachment; active chronic inflammation; mucosa engorged; numerous dilated prostatic ducts	Scirrhous; atrophy of mucosa; prostatic ducts cribriform
Verumontanum....	Surface edema; engorgement; enlargement; inflammation of ejaculatory duct openings	Enlargement; atrophy; distortion; patent ejaculatory ducts

The average age of our patients was forty-five years, five years less than that found in cases of fibrosis. Neisserian infection was denied in 25 per cent of cases. Ascending infection was the chief cause. However, occasionally stricture of the urethra, renal calculus, vesical calculus and vesical diverticulum were contributing factors. The chief complaint, in almost every instance, was frequency and dysuria. Nocturia, local and referred pain were often noted. Several patients complained of terminal hematuria. Residual urine was a variable factor. When present, it varied from a few drams to a half ounce. Rectal examination of the prostate showed a variation in size, from the normal to slight enlargement, from bogginess to firm, even consistency, and frequently the gland was tender. Sometimes, the seminal vesicles could be palpated. Microscopic examination of the prostatovesicular secretion showed increased pus content, single and clumped cells, and occasional organisms.

The diagnosis of prefibrotic bar is dependent on a careful history and thorough physical examination. Extraneous causes as well as the associated pathology in the genitourinary tract must be clearly defined and evaluated. Micturitional disturbance frequently overshadows the increasing difficulty in urination, the presence of which must be elicited by careful inquiry. Further questioning will reveal a history of progressive frequency and dysuria with diminution of propulsive force. There is evidence of pathology on bimanual rectal examination of the prostate and seminal vesicles. However, digital examination of the seminal vesicles may be misleading. Impression of vesicular infiltration may be simulated by an increase of the normal amount of fibroareolar perivesicular supporting tissue. The microscopic and cultural examination of the prostatovesicular secretions expressed by massage as recommended by Von Lackum, or by the method suggested by Ballenger and Elder, are more accurate gauges of the amount and degree of inflammatory pathology.

We believe that the most reliable index of prefibrosis as well as the associated adnexal pathology is provided by cystourethroscopic visualization of the lesions produced in the posterior urethra, verumontanum, ejaculatory and prostatic duct openings. These changes have long been recognized as reflecting the pathology present in the underlying adnexal structures and the trained cystoscopist should experience no difficulty in the recognition or estimation of the extent of the pathology.

Prefibrosis must not be viewed as an active chronic urethritis per se. It is a generalized dissemination of the infection involving the posterior urethra, vesical neck and subjacent glandular adnexa with an irregular inflammatory elevation at the vesical neck.

Provided the diagnosis and estimation of pathology has been made with the necessary precision, the treatment is almost self evident. It is based on a proper selection of cases. The eradication of remote causes such as stricture, vesical calculus, renal foci of infection, diverticulum and infection of the bladder is essential. Treatment of concomitant pathology, active inflammation in the subjacent glandular structures is also necessary. Conservative remedial measures to render the urine aseptic, ingestion of increased amounts of fluid, massage and local treatment of the prostate and seminal vesicles, application of heat, medicated fluids in the form of urethrovesical irrigations, or diathermy, instillations and dilatation of the urethra and vesical neck are some of the agencies which have proved of value.

Local treatment to the vesical neck in the early stage includes topical applications of mildly cauterizing agents and superficial diathermic desiccation with the McCarthy ball electrode or the Bugbee electrode. We have found that by direct anesthesia of the hyperplastic tissue, diathermy could be carried out painlessly with the Hyams hypodiathermic electrode. Several treatments may be necessary for the eradication of the more advanced types of prefibrotic elevations.

The treatment during the active inflammatory stage is obviously not that of operative removal of the inflammatory obstruction. The activation of the process and dissemination of infection by such a procedure may light up and cause a marked increase in subjective disturbance. Conservative remedial measures rather than surgical excision or destruction is the therapeutic indication. It is also suggested in those cases where the differentiation between prefibrosis and fibrosis is in doubt, or where active inflammatory manifestations persist after surgical removal of median bar.

The differentiation of the prefibrotic changes from those of the terminal fibrotic stage, at times, presents difficulties in diagnosis which must be tempered with a considerable degree of judgment and conservatism. The patient is often uncomfortable, at times impatient and urgent in his demand for immediate relief. The chronicity of the infection is apparent. Injudicious excision in these cases will not only prove unsatisfactory, but will be followed by an exaggeration of symptoms and an increase of disturbance, rather than the amelioration and the happy result encountered in those cases of median bar wherein a specific amount of obstructing tissue is removed. We believe the operative treatment should be reserved for those cases of quiescent fibrosis in which there is definite subjective and objective evidence of obstruction.

We wish to extend our appreciation to Dr. Charles Norris, Chief Medical Examiner of New York City, and to Dr. Thomas A. Gonzales, for their kind cooperation and for the use of the necropsy material utilized in this and previous studies.

VESICOVAGINAL FISTULA ADHERENT TO THE RIGHT PUBIC RAMUS

THE MANAGEMENT OF A DIFFICULT CASE*

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BOSTON, MASS.

WITH the general improvement of obstetric practice, vesicovaginal fistulae are much less frequently encountered than they were in the past. Most fistulae, due to the trauma of childbirth, are caused by pressure necrosis and sloughing rather than by forceps cuts or lacerations of the tissues. It is true that in most cases where an opening occurs between the bladder and the vagina the labor was terminated instrumentally. Etiologically the accident is due to the fact that the forceps were used after a long labor, when necrosis had already occurred, rather than when they were used too early. In some instances the bladder may be ground against the pubic ramus of one side or the other by the forceps. The technique of the surgical repair of these lesions is well standardized. The classical or Sims' operation, using silver wire, still has its adherents and the results are uniformly good. The closure of the bladder and the vagina in separate layers, with catgut, is also responsible for many satisfactory results. Rarely is it necessary to close a fistula transvesically. There are two types of fistulae, however, which offer great difficulties: (1) when there is extensive loss of tissue and (2) when the fistula is situated high in the vaginal vault and adherent to bone. An experience with the latter condition has led me to report the details of a case:

CASE REPORT

History. Mrs. H. C., a healthy, married young woman, twenty-eight years of age, first consulted me on July 9, 1929, complaining of a vesicovaginal fistula and consequent wetting of the vagina and the thighs with urine. She had had a difficult forceps delivery in a neighboring city after 80 hours of labor, in October, 1928, eight months before presenting herself for examination. The baby was said to have weighed 9 lb., 14 oz. and had been stillborn. Leakage of urine in the vagina occurred soon after delivery. Her family history revealed no abnormalities and she had always been in good health. Menstruation was established when she was fourteen years of age, her periods were regular, every twenty-eight days, lasted two to three days, the flow was scant, there was no pain and the last period had occurred on July 1, 1929. She had been married two years and had had two pregnancies, the first ending in an abortion, at two months, which was followed by a curettage of the uterus, and the second, by the forceps delivery already outlined.

Examination. The general physical examination showed nothing abnormal. The vaginal examination demonstrated a poorly healed right episiotomy which was filled with scar tissue, there was a small bilateral laceration of the cervix, the uterus was normal in size and position, freely movable and the adnexa were normal. There was a large vesicovaginal fistula admitting the tip of the small finger, to the right and behind the right pubic ramus, to which it seemed adherent. She was referred to the Carney Hospital for operation and, because of the inaccessibility of the fistula through the vagina, a transvesical closure was attempted under general anesthesia on July 18, 1929.

First Operation: Transvesical Closure of Fistula. An abdominal incision about 5 inches long, starting at the symphysis pubis, extending toward the umbilicus and going through the skin, fat and fascia was made. The recti muscles were separated, the pyramidalis was pushed to the right and the space of Retzius was exposed. The bladder was picked up and opened at the fundus, an incision about 4 inches long being made. The fistula was readily exposed on the

* From the Gynecological and Obstetrical Service of the Carney Hospital.

floor of the bladder and the right ureter was easily identified. The fistulous tract was denuded widely and closed in three layers with interrupted sutures, using No. 0 chromic catgut in the first two and No. 1 plain catgut in the bladder mucosa. A No. 34 Pezzer catheter was introduced in the bladder. The bladder incision was closed with a running suture of No. 2 chromic catgut, the fascia with interrupted sutures of the same material and the skin with interrupted sutures of silkworm gut, after placing a rubber dam drain in the space of Retzius. A retention catheter was placed in the bladder through the urethra.

Convalescence. The patient was returned to bed in good condition and made a good recovery from anesthesia. The highest temperature recorded was 100°F. on the first postoperative day; this subsided gradually, reached normal on the fifth day and remained so throughout her stay in the hospital. On July 25, seven days after operation, the urethral catheter and the rubber dam drain were removed. The vulval pads were wet with urine. Twelve days after operation the suprapubic Pezzer catheter was removed. She was allowed out of bed on the eighteenth day and discharged on the twenty-second postoperative day with a pin-point opening at the site of the original fistula, through which urine oozed.

Second Admission. The patient was readmitted on November 13, 1929, about three months after her discharge from the Carney Hospital. She had been up and around the house, wetting pads, but not so much as she had been previous to the operation. Examination showed the vaginal mucosa to be covered with a crust of urinary salts and the vagina was therefore treated until it was entirely healed. There was constant leakage and cystoscopic examination showed a small opening within the bladder sphincter. On December 3, 1929 a vaginal closure with silver wire sutures was attempted, under general anesthesia.

Second Operation: Vaginal Closure with Silver Wire Sutures. The fistulous opening, which was high, near the symphysis and close to the pubic ramus on the right, was denuded by sharp knife dissection. The opening was closed in one line with eight silver wire sutures. This seemed to make a tight closure. The vagina was tightly packed with gauze and the bladder filled with a solution of methylene blue. The gauze was left in for considerable time and on its removal there was absolutely no leakage and no discoloration of the gauze. A self-retaining catheter was introduced in the bladder.

Convalescence. She made an excellent recovery from anesthesia, her general condition was good and the temperature, pulse and respirations remained normal throughout her stay in the hospital. She remained well for ten days at which time some leakage appeared through the old fistula. She was discharged on December 16, 1929, thirteen days after operation.

Third Admission. She was admitted to the Carney Hospital for the third time on March 3, 1930, not quite three months after her previous discharge. There was still some leakage from the vesicovaginal fistula. Examination showed marked vaginitis and incrustation of urinary salts on the vaginal mucosa. The bladder was placed on constant drainage for five days and she was given urinary antiseptics, together with cleansing vaginal douches twice a day. This was continued until the vaginal mucosa was healed. On March 28, 1930, under general anesthesia, another attempt was made to close the fistula by the vaginal route.

Third Operation: Vaginal Closure with Catgut and Silver Wire Sutures. The fistula had almost completely healed except for a small opening at the upper aspect close to the symphysis pubis. A transverse denudation was made round the fistula, dissecting out a cuff of vaginal mucosa and undermining the edges of the vagina around it. The vaginal cuff was sutured over the opening by a continuous stitch of No. 0 chromic catgut, thus forming a plug of denuded vaginal mucosa directly over the opening. The undermined edges of the vagina were approximated over this with eight silver wire sutures. The primary result seemed satisfactory. A self-retaining catheter was introduced in the bladder and the patient returned to bed in good condition.

Convalescence. The general condition remained good and her temperature, pulse and respirations were normal throughout the convalescence. There was no leakage until the sixth postoperative day, April 3, 1930. She was discharged, still having a small amount of leakage, on April 9, 1930, twelve days after operation.

Fourth Admission. On June 26, 1930 the patient came to the Carney Hospital for the fourth time, still having urinary leakage. The vaginal examination revealed a minute opening at the top of the vaginal vault on the right. There was marked incrustation of urinary salts on the vaginal mucous membrane. These crusts were removed daily and the excoriated vagina painted with 5 per cent mercurochrome solution. In addition, antiseptic douches were given morning and night. The vagina having healed, a transvesical closure was performed, under general anesthesia, on July 8, 1930.

Fourth Operation: Transvesical Closure of Fistula. The previous median abdominal scar was resected. The bladder was exposed and freely opened. On the bladder floor, to the right, was found an opening which admitted the top of the index finger and which was firmly bound down to the pubic ramus by dense scar tissue. This scar tissue, at the edges of the fistula, was resected. A purse string suture of No. 2 chromic catgut was introduced in the vaginal wall, and when tied, it pulled the bladder well toward the pubic ramus, but did not entirely close the fistulous opening as there was too much tension. A layer of interrupted sutures of the same material was applied, bringing together the vaginal and bladder walls, but skipping the bladder mucosa, which was approximated over the two previous layers by a running stitch of No. 1 plain catgut. A No. 34 Pezzer catheter was introduced in the bladder which was closed by a continuous suture of No. 2 chromic catgut. A small rubber tissue drain was placed in the prevesical space, the fascia united with interrupted sutures of No. 2 chromic catgut and the skin and fat with silkworm gut. The patient was then placed in the lithotomy position, the vagina tightly packed with gauze and 30 c.c. of methylene blue solution introduced into the bladder. After five minutes the gauze was withdrawn, there was no staining on it and apparently the opening was closed tightly. A retention catheter was introduced in the bladder and the patient returned to bed in good condition.

Convalescence. She made a good recovery from the anesthesia, her highest temperature was 100.2°F. on the first postoperative day, it became normal on the fifth day and remained so thereafter. The sutures and drain were removed on the tenth day. There was no urinary leakage for three days, but from then on it was noticed. She was discharged, with some vaginal leakage, on July 26, 1930, eighteen days after operation.

Fifth Admission. Her fifth admission to the Carney Hospital occurred on January 21, 1931. Her general condition was excellent. She stated that her last period had occurred on January 9, 1931 and the previous one on December 12, 1930. Her vagina was treated as it had been before to remove the crusts of urinary salts and the fistulous tract was painted daily with 5 per cent silver nitrate solution. The cystoscopic examination, on February 3, 1931, revealed the following: The urethra was patulous and relaxed, the distending fluid escaped from the vagina almost as fast as it was introduced into the bladder, the sphincter edge was a little uneven and relaxed, the ureters were not seen, the fistulous opening could be made out in the angle between the posterior elevation and the sphincter edge on the right and the mucosa in this area was edematous. After consultation with Dr. A. McKay Fraser, it was decided to attempt an extraperitoneal closure of the fistula and this was done, under general anesthesia, on February 9, 1931.

Fifth Operation: Extraperitoneal Closure of Fistula. A transverse abdominal incision was made above the symphysis, cutting across both recti muscles and exposing the bladder extraperitoneally. The bladder was separated from the right pubic ramus and from the vagina; the adhesions were very firm. The right uterine artery, which was completely exposed, was ligated at its origin and cut. The right ureter was dissected for about 2 inches, up to its entrance in the bladder. The vaginal opening was about 3.75 × 2.5 cm. The vaginal wall was closed with interrupted sutures of No. 2 chromic catgut, which did not penetrate the surface vaginal mucosa. The scar tissue at the edges of the bladder opening was resected. In the dissection the superior surface of the urethra was exposed and opened. A self-retaining catheter was introduced in the bladder, through the urethra and the superior surface of the urethra closed over the catheter for an area about 2.5 cm. in length, by mattress sutures of No. 2 chromic catgut. The bladder opening, which was about 4 × 3 cm. and which was triangular in shape with the apex at the urethral opening, was closed with interrupted

sutures of No. 0 chromic catgut. This first layer of sutures was covered over by the bladder muscularis using a running stitch of the same material. At the completion of this part of the operation the bladder and vaginal openings were far apart. A Penrose drain was placed at each angle of the abdominal incision to the base of the bladder on each side. The recti muscles were attached to the periosteum of the pubes with interrupted sutures of No. 2 chromic catgut, the fascia was approximated with interrupted sutures of the same material and the skin and fat were closed with silkworm gut. The catheter was left in the bladder. The peritoneal cavity was not opened at any time during the operation and the patient was returned to bed in good condition.

Convalescence. Three days after operation there was some urinary drainage through the vagina and through the abdominal incision. The sutures were removed on the tenth day, the catheter on the sixteenth day and the drains on the twenty-second day. She was discharged on March 6, 1931, twenty-five days after operation with the abdominal wound well healed and no leakage through the bladder fistula. The bladder held considerable urine which the patient voided at intervals. Necrosis had occurred in the dissected portion of the right ureter and a small right ureterovaginal fistula had developed.

Sixth Admission. On August 18, 1931 the patient was admitted to the Carney Hospital in labor. The fifth operation had been successful in closing the vesicovaginal fistula, but a small right ureterovaginal fistula had developed. She was pregnant when the last extraperitoneal operation was done, but pregnancy had not been suspected since the marked incrustation of the vagina had made us think that coitus was not possible and because she stated that she had had a regular period twelve days before entering the hospital. She went through pregnancy uneventfully except for the leakage of a small amount of urine from the fistula of the right ureter. As she reached term, because of a generally contracted pelvis and because of the scar tissue in the region of the bladder following the five operations, it was decided to do a classical cesarean section. She had been in labor about four hours, the membranes were intact and no vaginal examinations had been made.

Sixth Operation: Classical Cesarean Section. Under nitrous-oxide-oxygen-ether anesthesia, a left rectus incision, two-thirds below and one-third above the umbilicus, was made, going through the left rectus muscle. On opening the peritoneal cavity no adhesions whatsoever were found. An incision about 5 inches long was made in the anterior wall of the uterus and a female child, weighing 6 lb., 15 oz., and who cried spontaneously, was delivered by the breech. One cubic centimeter of gynergen was injected intramuscularly at the start of the operation and 1 c.c. of pitocin after the delivery of the baby. The placenta was extracted through the incision and the uterus contracted well. The uterine incision was closed in two layers, the first with interrupted sutures in the musculature, skipping the endometrium, and the second with a continuous suture in the serosa covering over the first layer. No. 2 chromic catgut was used as suture material. The abdominal wall was closed in layers. Both mother and baby were in good condition at the end of the operation.

Convalescence. The patient made a good recovery from anesthesia. On the first postoperative day the temperature rose to 100.4°F., the pulse was 100 and the respirations were 22. On the fourth day the temperature rose to 100.8°F., sepsis of the abdominal incision was discovered and a drain inserted to the fascial layer. She improved gradually, the sepsis clearing up and the temperature subsiding. On the eleventh day the temperature was normal, it remained so for twenty-four hours, at which time it began to rise again. On the fourteenth postoperative day it reached 101.8°F., the pulse 100 and the respirations 22, the abdominal incision separated and a loop of ileum was extruded. She was prepared for operation.

Seventh Operation: Reduction of Loop of Ileum. Closure of Incision. Spinal anesthesia was induced, using 120 mg. of novocaine crystals dissolved in spinal fluid. The abdominal wall was prepared with ether and iodine. The loop of ileum, which was extruded, was washed with salt solution and replaced in the abdominal cavity. The uterus, which was seen at the lower part of the incision, seemed to be large and subinvoluted. The omentum was brought down to cover the intestines, a cigarette drain was placed behind the uterus and the incision closed with through-and-through silkworm gut sutures. She was returned to bed in good condition.

Convalescence. The convalescence evolved without complications. The drain was removed on the third day, the sutures on the ninth, and the incision found to be well healed. Both mother and baby were discharged, in good condition, twelve days after the operation.

Seventh Admission. The patient entered the Carney Hospital on January 12, 1932 for the treatment of her right ureterovaginal fistula. Her general condition was good.

Cystoscopic Examination. On January 14, a cystoscopic examination was done, with the following findings:

Urethra. A little uneven and snug to a No. 21 cystoscope. There was no pain or bleeding.

Bladder. Good tone and capacity; left ureteral orifice normal. On the right side the trigonal area was raised and mildlydistorted; the mucosa, especially in this region, was edematous and bled easily. There was an area of granulation tissue possibly at the site of the repair. No right ureteral orifice could be found even with the aid of indigocarmine.

Ureters. Left: A No. 2 catheter was easily introduced for 30 cm. normal drip. Urine: No pus, blood or casts. The indigocarmine appeared from the left kidney fairly promptly and with excellent intensity of color. Right: Neither indigocarmine, injected intravenously, nor 20 c.c. of 2 per cent mercurochrome subsequently injected through the right catheter in the vaginal opening appeared at any time in the bladder fluid, even after a long period of observation.

Pyelograms. The films show kidney shadows which are normal in size and position, the right a little larger than the left; there are no stones. The right pyelogram, made with 20 to 30 c.c. medium, shows slight dilatation of the collecting portion of the pelvis and the inferior major calyx. No *x*-ray fluid reaches the bladder, completing the proof that there is no communication between the bladder and the right ureter. The left pyelogram, made with 10 c.c. medium without pain, is normal.

Eighth Operation: Implantation of Right Ureter in Fundus of Bladder. The operation was performed on January 23, 1932, under general narcosis. A catheter was introduced in the right ureter up to the pelvis of the kidney through the fistulous opening in the vagina. The bladder was filled with about 12 oz. of saline solution through a mushroom catheter, introduced through the urethra. A right rectus incision, extending from the umbilicus to the symphysis pubis, was made. After incising the fascia, the right rectus muscle was dissected from its fellow in the median line and pulled toward the pelvic wall. After some dissection the right ureter was easily identified because of the catheter running through it; it was mobilized and dissected on all sides up to its opening in the vagina, where the fistula existed. A Kelly clamp was placed on the end of the ureter close to the vagina; the ureter was then cut, bevelling the end, which could be brought to the fundus of the bladder without undue tension. A small opening was made in the fundus of the bladder and the ureter was picked up anteriorly and posteriorly by sutures of No. 0 plain catgut which went into the musculature but not into the lumen. The ends of the suture were passed through the bladder wall and tied outside of it, thus bringing the ureter within the bladder cavity. The bladder was then closed about the ureter and over the end of it by a row of interrupted sutures of No. 0 chromic catgut, picking up the bladder musculature. A Lembert suture of No. 0 chromic catgut was placed in the bladder wall to cover the first row of sutures. At the completion of this procedure, the ureter was well implanted in the bladder, it was covered over by two rows of bladder wall and there was no undue tension. A cigarette drain was placed at the bottom of the dissected area to the right of the ureteral implantation and the abdominal wall closed in layers. She was returned to bed in good condition.

Convalescence. The temperature varied from 99° to 103°F. for a period of ten days, it then dropped to normal and remained so for three weeks. On the twelfth postoperative day the drain was removed and four days later the wound was entirely healed. She had been voiding urine in large amounts and was to be discharged the next day when she had an attack of acute tonsillitis, with a temperature of 105°F., which, however, rapidly subsided.

The cystoscopic examination on February 26, 1932 showed the anastomosis on the right posterolateral wall firmly healed and epithelialized. There was a small round opening about 2 mm. in diameter present; no urine was seen coming from this. No persistent attempt was made to pass the catheter for fear of trauma so soon after operation. There was no bleeding, no pain and the bladder urine showed pus cells in the sediment. The films of the

genitourinary tract, after intravenous uroselectan, visualized the left kidney pelvis, calyces, ureter and bladder normally, the right pelvis and calyces visualized faintly; the right kidney showed some enlargement.

The discharge examination showed the abdominal incision solidly healed. The vaginal examination showed slight relaxation of the introitus, no cystocele or rectocele; the cervix was healed, it was high in the vaginal vault and showed no erosion; the uterus was normal in size and position, movable, and the adnexa were normal. There was no leakage from the vagina and she was discharged on February 27, 1932.

Follow-up. On May 20, 1932 the patient was in excellent general health and was absolutely free from symptoms. The abdomen was normal, and, in the absence of a mass in the right renal area it seemed that the right kidney had gone down to normal proportions or had undergone atrophy as a result of complete obstruction of the lower ureter. The bladder floor was greatly distorted by the many operations and the right ureteral opening could not be found with certainty. Indigocarmine, intravenously, gave evidence of very excellent function on the left side, but failed to give any conclusive proof of activity on the right.

On June 24, 1932 intravenous urograms were made, in an effort to throw further light on the question of the function of the right kidney. The films were quite satisfactory, but the right renal pelvis and right ureter were not outlined, suggesting a lack of excretory function on that side. The left kidney outline looked a little larger and decidedly larger than the right kidney shadow. This possibly represented some compensatory hypertrophy on the left side and, perhaps, some atrophy on the right. This evidence, which was at variance with the clinical history, suggested pretty strongly that the right kidney was not functioning and probably was not in communication with the bladder. The patient was enjoying the best of health.

SUMMARY AND COMMENT

A woman, twenty-eight years of age, developed vesicovaginal fistula following an instrumental delivery, after eighty hours of labor. She was examined eight months after the accident, when it was discovered that the fistula was behind the right pubic ramus to which it was firmly adherent. The first four attempts at closure, two transvesical and two vaginal, were unsuccessful. At the fifth operation the recti muscles were cut across and the fistula reached extraperitoneally. It was shown, at this operation, that the failure of the first four attempts was due to the fact that it had not been possible to separate the bladder from the pubic ramus while operating transvecially and intravaginally. The extraperitoneal route permitted the free mobilization of the bladder which made the large rent in it readily accessible for closure. At this operation the lower part of the right ureter had been dissected free from the surrounding tissues in order to identify it while the sutures were applied. The bladder rent was successfully closed but the patient developed a ureterovaginal fistula on the right. This might have had a chance to close spontaneously had the patient not been pregnant and had the pregnancy not caused upward traction on the ureter. Pregnancy had not been suspected, at the time of operation, since it was deemed impossible for coitus to take place through a vaginal tube incrusted with lime salts. Again, the incrustation and marked vaginitis kept up bleeding each day so that she could not keep track of her menstruation. The pregnancy reached term without complications and she was delivered of a living female child by a classical cesarean section, a cervical cesarean section being thought inadvisable because of the many operations on the bladder. On the fourteenth postoperative day the abdominal incision separated and a loop of ileum was extruded. Under spinal anesthesia the small intestine was returned to the peritoneal cavity and the incision closed with through-and-through silkworm gut sutures, a small drain having been inserted at the lower angle of the abdominal wound. The patient made a good recovery and was discharged in good health. Five months later the right ureter was implanted in the fundus of the bladder and the leakage was

stopped. Suprapubic drainage was considered at the time of this intervention and might have prevented back pressure against the newly implanted ureter but the scar tissue in the bladder was so dense that this was given up and drainage maintained by a retention catheter placed in the bladder through the urethra.

Functionally the outcome is not as satisfactory as I had hoped since the follow-up examinations seem to demonstrate that the kidney has atrophied and is probably not functioning. While it is true that a good result might also have been obtained by a nephrectomy, I believe that the method chosen was the better one as there was, at least, a fair chance of obtaining a functioning kidney. I am convinced, now, that suprapubic drainage might have been helpful in keeping the lumen of the newly implanted ureter patent. Clinically, and from the patient's standpoint, the result was eminently satisfactory, for, after nearly three and one half years of urinary incontinence and discomfort she is now free from symptoms and in perfect health.

Note: I am indebted to Dr. Roger C. Graves, Chief of the Urological Service of the Carney Hospital, for doing all of the cystoscopic work in this case; also, to Dr. A. McKay Fraser of the Surgical Service for many valuable suggestions.

A BIOLOGICAL, BACTERIOLOGICAL AND CLINICAL STUDY OF

LARVAL OR MAGGOT THERAPY IN THE TREATMENT OF ACUTE AND CHRONIC PYOGENIC INFECTIONS*

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LARVAL or maggot therapy in the treatment of acute and chronic surgical infections is still in its infancy. Our own observations and results to date, and those published by others, have shown that it is of great surgical value, and that further study and investigation are justified.

During the past two years we have carried on a careful biological study of the blow-fly and its larva, including methods of sterilization, its associated bacteriology and its behavior and activity when implanted into human tissue.

This study constitutes the object of our presentations and we desire to report our results with the hope that it may stimulate other workers in a very useful therapy and assist in simplifying the procedure so that it may come within the reach of those engaged in the treatment of acute and chronic surgical infections. The maggot adventitiously introduced into the unprotected wounds of man and animal has undoubtedly saved many lives and a summary of certain facts supporting such views may be of assistance in establishing the importance of this problem.

Goldstein's excellent review of the literature introduces records pertaining to the adventitious presence of maggots in human wounds dating back to antiquity, and a digest of these records conforms closely to the important facts expressed by Baron Larrey in 1829, namely: "These insects accelerated cicatrization by shortening the work of nature and by producing an elimination of the necrotic cells by devouring them without disturbing living tissue." Such were the findings in the days of "laudable pus" when conditions aided maggot development, a feature which was brought to my attention by an elderly male nurse at the Mercy Hospital in 1910, when he referred to the elimination of infection and the reduction of pus development by the presence of maggots in the packing of sawdust surrounding compound fractures, a method in use before the advent of antisepsis.

These important facts attracted the attention of various surgeons during the World War, such as Crile, Martin, Slesinger of England and others but notably the late Dr. W. S. Baer, whose experience of encountering a healthful condition of the wounds of two neglected soldiers after they had become infested with maggots stimulated his interest in the investigation and development of this new method of viable antisepsis.

Records of the deliberate introduction of maggots into infected wounds were almost non-existent until Dr. Baer announced his maggot treatment for chronic osteomyelitis in 1930. A treatment, doubtfully placed in the category of deliberate introduction, is that used by the Maya Indians for the removal of superficial malignancy, in which a dressing of beef blood, after having been ceremoniously exposed to the sun (when flies deposited eggs on it), was placed over the tumor and in a few days was noted to pulsate (due, of course, to the wriggling of maggots). This in brief is the treatment described by Walhauser, of the University of Pittsburgh. However, the credit for

* Read before The Society for Biological Research, School of Medicine, University of Pittsburgh, Feb. 18, 1932.

the development of maggot therapy upon a scientific and practical basis must be accorded to W. S. Baer.

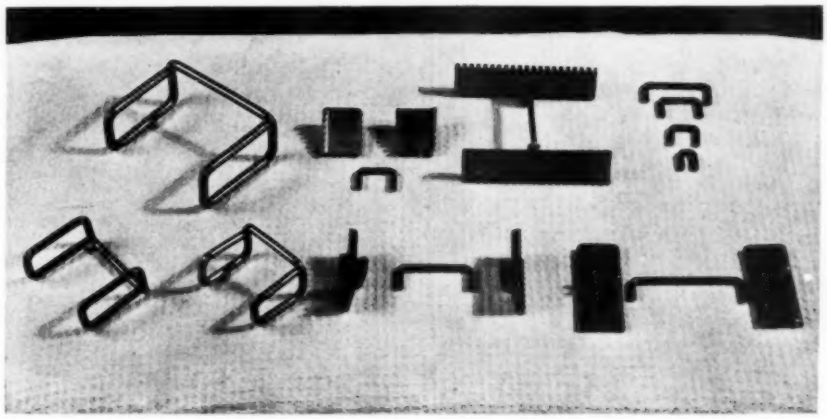

Fig. 1. Old and new type of self-retaining retractors.

ON THE BIOLOGY OF THE BLOW-FLY, AND THE CULTIVATION AND STERILIZATION OF ITS LARVAE

Not all meat-eating flies can be used with safety in wounds. Those belonging to the sub-family Calliphorniae are the ones to be employed. Of these the bronze-green blowfly (*Lucillia sericatta* or *L. caesar*) is quite efficient and the most convenient to handle in the laboratory. Others that have been used without ill effects are: the blue-black bottle fly (*Phormia regina*) and the large blue bottle flies (*Calliphora vomitans* and *C. erythrocephala*). The typical flesh flies belonging to the family Sarchophagedae are to be avoided, since they are able to destroy living tissue. The most common examples of this group are the bristly, grey and black flies belonging to the genus Sarchophaga and the screw worm (*Chrysomia macellaria*). We have found that the larvae of *Lucillia sericatta* will starve on clean granulation tissue.

Considerable literature is available dealing with the methods of providing and maintaining a colony of flies. Practically all of the investigators have taken elaborate precautions to maintain the health of the colonies, including such devices as forced draft, predigested proteins, artificial light at night and many other luxuries to which the fly in the wild is unaccustomed.

We have found that under the following conditions we obtain healthy flies and a constant supply of fertile eggs. The flies are confined in cages having a volume of a little over one cubic foot. These cages are kept in a glass-enclosed incubator maintained at a temperature of 78°F. A high humidity is maintained by evaporation from the surface of sponges floating in a pan of water. The circulation of air is brought about by the difference in temperature between the room and the incubator. Air enters small holes in the base and leaves through similar holes in the top. In warm weather, circulation is assisted by a fan. Exposure to sunlight is desirable, but artificial light will serve. The flies are fed a mixture of three-fourths orange juice and one-fourth strained honey through the medium of a pad of gauze. Water is kept before them in the same manner, a medicine glass full of wet gauze being the supply. Uncooked lean meat contained in glass vials is exposed to the flies for six hours in the middle of the day. This supplies the needed proteins and also a place for the deposit of eggs. With one to two hundred flies in a cage, the sex ratio is unimportant.

The rearing of stock flies is even more simple. Raw meat and fly eggs are placed in a pint mason jar with a piece of fine cheesecloth bound over the top. This is

then placed in a vented incubator at room temperature. When the maggots appear to be full grown, a handful of loose gauze is placed in the jar. If the gauze becomes moist, more is added. The maggots require a dry environment in which to pupate, and the gauze supplies this condition. The maggots pupate much more quickly, with much less mortality and are more easily handled in the gauze than in sand. This method was discovered by Dr. W. S. Nettrour in our laboratory.

The dangers of the introduction of virulent organisms into the wounds along with untreated maggots were shown by several workers and methods of sterilization were developed. The first method, developed in Dr. Baer's laboratory at Johns Hopkins, is as follows. The freshly laid eggs are soaked in water and mechanically separated with the aid of a spatula and by violent shaking. They are then soaked for one-half hour in a $\frac{1}{1000}$ solution of bichloride of mercury with 1 per cent hydrochloric acid added. This solution was later modified by using dilute alcohol as a solvent in place of water. A sample of the eggs was crushed and tested for bacteria. If these showed no growth, the maggots were considered sterile.

The second system of sterilization involved a substitution of a chemical separation of the eggs for the mechanical separation. The sterilizing fluid remained the same. The system was worked out independently in at least two laboratories, by F. F. Murdoch and T. S. Smart in the U. S. Naval Medical School at Washington, and in our own.

A brief of the technique published by Murdoch and Smart[5] follows: The eggs

FIG. 2.

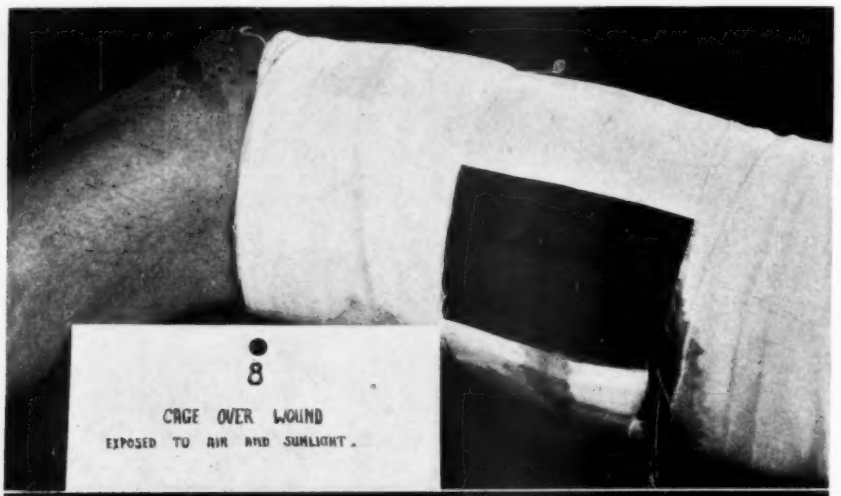

FIG. 3.

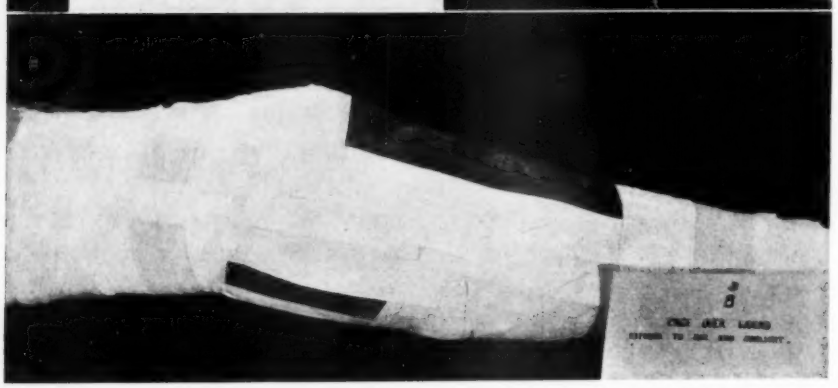

FIG. 2. Application of dressing cage consisting of 70 mesh copper screen and adhesive tape.
FIG. 3. Application of anterior and posterior dressing cage.

are shaken in water and then in a 1 to 2 dilution of Dakin's solution for one minute, the Dakin's solution having .39 per cent available chlorine. The eggs are then washed for one-half hour in a stream of 1/1000 bichloride of mercury during which time they are shaken gently. The technique developed in our laboratory differs in minor details of apparatus and in the addition of a step between separation and sterilization. In this step the unseparated clumps, after the Dakin's solution bath, are picked out by hand.

The third technique developed by Edw. F. Roberts of Pearl River, New York,[12] also uses sodium hypochlorite for separating the eggs and uses formaldehyde for sterilization. In brief his method is as follows: The entire process is carried out in a covered Gooch crucible. The eggs are first washed with sterile distilled water, then soaked one-half to one minute in a solution of sodium hypochlorite having .5 per cent available chlorine, rinsed again in sterile water and then soaked three minutes in a neutral 4 per cent solution of formaldehyde. The eggs are incubated at 70°F. and tested for bacterial contamination. The test employed is to use duplicate sets of fermentation broth tubes and deep meat tubes. The cultures of the developing larvae were taken at the end of twenty-four hours' incubation.

The system in use in our laboratory at the present time is a combination of all of the foregoing techniques. The eggs are shaken for two to five minutes in a solution of sodium hypochlorite having about .12 to .15 per cent available chlorine. All remaining clumps are removed by hand picking, the eggs thoroughly washed in sterile water, then constantly agitated in 4 per cent formaldehyde solution for four or five minutes, and then washed again and implanted on sterile meat-agar media.

During the past year we have used, at one time or another, all of these methods. We have followed the directions given by the originator of each technique with the utmost care for asepsis. All apparatus and equipment used have been either baked or autoclaved. Our bacteriological

Fig. 4. Ulcerating carcinoma of breast showing application of self-retaining retractors.

laboratory has found, by composite cultures of an entire day's production, that none of these techniques give completely sterile maggots in quantity. We do not mean to infer that such maggots are unfit for use, because, as will be shown, they are free from virulent pathogens after treatment with the more efficient of these techniques.

Early attempts at sterilizing the maggot when it has reached the size best suited for implantation into wounds have been almost totally unsuccessful. This is due to the fact that the bacteria are within the gastrointestinal tract of the maggot and cannot be reached by chemicals because of the impermeable chitinous skin and the fact that the maggot will not swallow the chemical. The bath in 1/1000 bichloride of mercury is entirely ineffective, and even a solution ten times as strong fails to penetrate into the maggot or otherwise effect sterilization. Maggots will swim about for as long as two hours in Bouin's or Zenker's fixatives, an indication of their resistance to penetrating liquids.

One procedure which we have developed within the past eight months indicates that sterilization of the partly grown maggot is possible. The degree of success

in this treatment is encouraging, and we present it as a report of progress rather than a finished investigation. This treatment is used only on the maggots that show contamination after egg sterilization. The basis of the treatment is a solution of iodine in a special salt solvent developed for antiseptic purposes by George M. Karns, Senior Fellow of Mellon Institute of Industrial Research, Pittsburgh, Pa. The maggots are immersed for one-half hour in this solution diluted to .05 per cent free iodine strength. When removed from this bath, the maggot is a bright orange in color, but fades to a pale creamy white within a few hours. In 40 per cent of the cases where maggots of known contamination have been so treated, we have been unable to recover the bacteria from the maggots, even when some of the maggots have been permitted to live in the bacteria culture medium for several days. The iodine, if used full strength (2 per cent) kills the maggot within a few seconds, probably by strangulation, and we believe that in the dilution we use that it reaches the gastrointestinal tract. We do not think that the iodine penetrates the skin, and it is doubtful that the maggot swallows it. The iodine apparently enters the maggot through the breathing tubes in the form of a gas. Since these breathing tubes ramify through all parts of the body of the insect, the iodine is absorbed into the tissues through this medium.

FIG. 5. Osteomyelitis of femur showing exposure of bony structures with self-retaining retractors.

The first test for bacteria, used by early investigators, was to culture a sample of the eggs. This was done either by crushing the egg and then culturing it, or by permitting several eggs to hatch on an agar slant. Experience has proved that such a test is non-indicative, for many batches of eggs that showed no bacteria when tested were found to be heavily contaminated at the end of the thirty-six hour period of incubation. A second test was to make a direct smear of the median in which the maggots had been feeding. This also *proved non-indicative* because broth cultures taken at the same time showed contamination. The only reliable test seems to be to culture *some of the food* in which the maggots have been feeding, or the maggots, in broth and deep meat tubes. Here, too, the conditions under which the maggots were incubated and the time of testing determine the reliability of the test. We have found that if the maggots are incubated at from 21 to 25°C. (70 to 77°F.) bacteria seldom appear in cultures taken at twenty-four hours, but may do so later. This appears to be the rule rather than the exception. When the maggots are incubated at 32°C. (90°F.) bacteria may not show up in cultures taken at eighteen hours, but if there is any flora at all, it will be grown out from cultures taken at forty-eight hours.

The results of our experimenting with the foregoing methods and tests may be summarized as follows:

1. Before being placed in the sterilizing solution, the eggs must be *completely* separated and at least part of the cementing material removed from the egg.

2. The eggs must not become sticky and clump together in the sterilizing solution.

3. Soaking in water merely increases the mortality rate of the eggs.

4. Any solution of sodium hypochlorite strong enough to completely separate

all clumps will leave the eggs in such a condition that they will agglutinate if placed in water, bichloride solution or formaldehyde solution; therefore, a weaker solution must be used and the remaining clumps picked out by hand.

5. Any solution of bichloride of mercury strong enough to destroy all the bacteria is either lethal or nearly so to the eggs.

6. Removal of bacteria from partly grown maggots on which the egg sterilization has failed is possible by treatment with a dilute aqueous solution of iodine.

BACTERIOLOGICAL STUDIES OF THE MAGGOT OR LARVA OF THE BLOW FLY, AS FRODUCED FOR USE IN SURGICAL WOUNDS

Introduction. The material presented in this paper is based on cultures made from 140 different broods of maggots grown to be used in the larval treatment of certain surgical conditions. A brood consists of all the maggots hatched from a single day's supply of eggs, sterilized and planted in 3 to 10 bottles of sterilized food. The technique applied in this study was in general the same as that used in the bacteriological laboratory at the Mercy Hospital, differing only in certain details as the specific conditions demanded. This work was done during the development of a technique for egg sterilization.

Part 1. All cultures of the first 100 broods were taken from maggots grown from sterilized eggs on sterilized media for forty-eight hours at 32°C. Routinely the culture was made from one of a series of 3 to 10 bottles in which the sterilized eggs had been distributed. Infusion broth, blood agar plates, and cooked meat media were inoculated as the primary cultures, from which the organisms were identified by the usual methods. Direct smears stained by Gram's method were made as a check on the quantity and variety of organisms present.

It was immediately found that routine twenty-four hour incubation of broth prior to plating gave a plate too heavily grown to be picked. The time of incubation of the original broth cultures had to be reduced from twenty-four hours to only one-half hour before streaking the blood agar plates. Later, as the technique of egg sterilization was improved, this time was increased to two hours, then to four hours, and finally to eight hours, an increase of 16 times the incubation period originally found practicable. At the same time direct smears were showing less and less contamination until they were always found negative and were discontinued. As a refinement the seventy-two hour period of incubation to determine absence of growth was increased to ninety-six hours.

The total number of different forms of bacteria isolated was 35, which may be divided as follows:

Gram-negative bacilli	16
Streptococcus forms	6
Staphylococcus forms	5
Gram-positive bacilli	5
Gram-positive micrococci	2
Gram-negative coccus	1
	35

Only 4 of the 16 Gram-negative bacilli could be classed as pathogenic forms; and these were (1) B. pyocyaneus, (2) B. alkaligenes, (3) B. proteus, and (4) B. coli communior. The others belonged to the large group of soil and water forms. Of the streptococcus forms, 5 were of the green streptococcus group and the remaining one was Streptococcus pyogenes vulgaris. The staphyloccus forms were the usual varieties of Staphylococcus albus, Staphylococcus aureus, and Staphylococcus epidermidis. The Gram-positive bacilli were chiefly diphtheroids. One Gram-positive micrococcus was Micrococcus tetragenes, the other was unidentified. The Gram-negative coccus was also unidentified.

In the order of frequency of occurrence, Staphyloccus albus occurred in 57 per cent of the broods, chiefly as a non-hemolytic variety. B. proteus occurred in 22 per cent. Then followed an unidentified staphylococcus which occurred in 11 per cent; and

Staphylococcus aureus in 9 per cent. Besides these, 13 different organisms occurred only once throughout the group of maggot broods studied.

The highest number of different bacterial forms in any single brood of maggots was 4; and this occurred only ten times, six of which occurred early, at a time when the technique of egg sterilization was being developed. Three bacterial forms occurred in each of 12 broods; two, in each of 36; one only in each of 26; and none in 14 broods. Of these latter 3 showed bacteria in direct smear, though none grew out in culture, leaving 11 supposedly sterile broods.

When a broad view of the bacterial distribution was taken certain factors were noted. The soil and water forms occurred at the beginning and at the end of the study, along with pathogenic forms other than B. proteus. There was a period of three months when B. proteus and Staphyloccus albus were present with an occasional streptococcus form, but with scarcely any soil and water forms. In fact, during this time practically every brood of maggots was contaminated with B. proteus. Staphylococcus albus was the most common contaminator throughout the entire experiment.

A study of control cultures of wounds taken before and after the implantation of maggots showed no consistent change in the flora of the wounds. An exception must be made in the case of B. welchii, the eradication of which from wounds will be referred to in another part of the paper.

That sterile maggots can be grown with the technique now employed was proved a number of times by incubating a single egg planted on a plain agar slant. A maggot produced under these conditions did not grow rapidly because of lack of food, but did remain sterile. One such control was permitted to pass through its pupa stage and an adult fly was obtained that was free of bacterial contamination. However, it seems clear that to grow maggots in sufficient quantity for larval treatment of wounds it is virtually impossible to obtain them free of any contamination, with the technique of egg sterilization as so far developed.

Part II. This fact was brought out more definitely in a further study of 40 broods of maggots in which composite cultures were taken at intervals of sixteen, twenty-four, and forty hours. A composite culture consisted of taking material usually including one or more live maggots from each of the bottles in which the brood was distributed. It was found by the composite culture method that 57 per cent of the broods were sterile after sixteen hours. At the end of twenty-four hours 50 per cent of these same broods were still sterile. At the end of forty hours, however, all showed contamination.

At the time the present group of 40 broods was studied, an iodine solution was being employed to sterilize the partly grown maggots that showed contamination after egg sterilization, just before they were implanted into wounds. To test the efficacy of the iodine treatment, composite cultures were made of the maggots from the 40 broods, after they had been so treated. They showed 40 per cent of the broods to be sterile after ninety-six hours incubation, while the cultures from the remaining 60 per cent showed relatively fewer organisms than were found in the afore-noted composite cultures from these broods prior to the iodine treatment.

Summary.

1. A single egg can be sterilized and a sterile larva and fly grown from it.

2. Working with a mass of eggs, sterilization would appear to be much more difficult, apparently because of points of contact between two or more eggs.

3. Using a single bottle from a series on which a brood had been grown, bacteriological study showed 10 per cent of 100 broods to be sterile.

4. When "composite" cultures were made at intervals during the growth of

the larva, the incidence of contamination increased as time went on, with 100 per cent contamination found by this type of culturing, after forty hours.

5. The degree of bacterial contamination decreased as the technique of egg sterilization improved.

6. The total number of kinds of organisms in any one brood of maggots was found to be very small.

7. Among these, pathogenic forms were few and occurred rarely.

8. The iodine treatment of contaminated partly grown maggots was shown bacteriologically to be efficient in 40 per cent of broods.

CLINICAL STUDY OF THE USE OF THE BLOW FLY LARVA IN SURGICAL CONDITIONS

The efficacy of larval therapy is difficult to establish at this early date in degrees of percentage and in order to determine its virtue in the treatment of acute and chronic pyogenic infections, it seems better to do so by comparative results with other forms of therapy.

This procedure is so foreign to the present and past methods of wound treatment that it may easily fall into disrepute, if not organized and conducted properly. With this thought in mind we have devoted special attention to its clinical application.

In our work as already described, we have made every possible attempt to obtain complete sterilization of our larvae, with methods devised by ourselves and those of others with certain modifications. Our results after long incubation of cultures taken from a brood of treated larvae show a good proportion unsterile, containing unidentified organisms and certain nonpathogens. This finding, associated with the open type of wound dressing, precludes the possibility of maintaining strict asepsis throughout the treatment; nevertheless, we have attempted in our work to standardize a careful surgical technique so as to avoid any foreign contamination.

The technique of implantation of larvae into the wounds as originally devised, required considerable time. Our present method, however, simplifies the procedure to a point where it compares favorably with the ordinary surgical dressing. Twenty-four hours following operation, after the wound and the focus of infection have been completely exposed, or immediately, if proper exposure exists in recent lacerated wounds, the plain gauze packing is removed from the wound and the surrounding healthy skin surface is cleansed with alcohol and ether. This is followed by an application of mercurochrome and later collodion. This procedure prevents the development of a possible dermatitis and relieves the patient of any irritation which may result from the larvae crawling upon the skin surface. The wound is then held open by the insertion of small metal self-retaining retractors, (specially devised for this work), followed by the implantation of treated larvae. The wound is immediately covered by a No. 70 copper mesh screen, supported by adhesive tape which attaches it to the skin. This dressing should be applied carefully without creases and the surrounding margin supported by a bandage.

The patient is then placed into bed and the wound so arranged as to give proper drainage by gravity if possible, and to receive the benefit of light and heat supplied by the ordinary electric light bulb. Should the dressing be small and the temperature permit, he is assigned as an ambulatory case. This type of dressing is simple yet very effective and one can dispose of many dressings in a short period of time.

A study of the clinical phase of this work by Baer, Murdoch, Stewart, Martin, Crile, and others has already brought forth many interesting points which have been very helpful; however, much work is yet to be done in establishing this therapy on a practical basis. For this reason we have endeavored to make careful observations. The assistance rendered by

our entomologist, Mr. Sweadner, in providing a constant supply of carefully prepared forty-eight hour old larvae relieves the surgical department of much work.

A preliminary bacteriological study of all wounds is made before the implantation of the larvae, followed by subsequent cultures at each dressing in order to show qualitative and quantitative changes of the bacterial flora of the wounds. As already shown in our bacteriological study little or no qualitative changes occurred, which confirmed our own clinical findings in the absence of any wound complications. The quantitative bacteriological variations correspond again to our clinical findings which were coincident with the reduction of the infection.

To accomplish the greatest degree of larval activity within the wound we have found it essential to select healthful appearing and active forty-eight hour old larvae. Excessive heat as may occur when a too hot solution is used for transferring the larvae from the original container to the wound, or upon their final immersion into stronger chemicals, reduces their activity and renders them less potent for wound service. We find it important to store the larvae at refrigerator temperature until the time of implantation.

Conditions within the wound must be ideal for their best performance. Wide open drainage with proper exposure of the foci of infection is a most essential factor and without this little can be expected from the implanted larvae. The self-retaining retractor prevents the closure of the wound, and also the development of sinus tracts before the deeper infection, such as is found in osteomyelitis, has been eliminated. The larvae work under great difficulty and accomplish little in sinus wound infections unless there is through and through drainage.

Continuous drainage of the wound is likewise very important in preventing the accumulation of serum and products of liquefaction necrosis. We have used several methods, first, siphonage, by a gauze wick or a small rubber tube contained under the wound covering; second, which we feel is a better method when convenient, by placing the wound in such a position as will permit the fluid content to be removed by gravity, which can be absorbed by sufficient dressing; or third, by permitting the contents to flow into an underlying container.

In keeping the wound clear of fluid the larvae are permitted to extend their activity over the entire wound, particularly at the seat of infection. The larvae under such conditions remain healthful and active and very few are found dead when the dressing is changed on the third day following implantation. Following this technique the general febrile reaction has been reduced to a minimum and an elevation of temperature beyond 99°F. is rather the exception.

Coincident with the removal of necrotic and devitalized soft structures is the development of highly vascular granulation tissue, which excretes abundant serum and which may be looked upon as a very beneficial factor in wound defense in this form of therapy. This may also play a role in the rapid elimination of the wound organisms. The apposition of granulating wound margins following larval therapy brings about a rapid development of granulation tissue, which can often be noted within a few hours.

In contrast to the above finding, when the larvae come in contact with exuberant and edematous granulations they attack it vigorously, and remove it as they do with any other abnormal structure, after which the change to healthy granulation tissue soon occurs.

We have observed that the larvae will attack almost any type of abnormal viable structure, including malignant tissues as well as devitalized soft or bony tissues. We have never observed the complete liquefaction or total destruction of devitalized bone, yet the manner by which it attacks the sequestrum at its

junction with normal bony tissue is amazing. In several cases we have observed the detachment of sequestra measuring 4 cm. by 2 cm. with but only four implantations of the larvae, leaving a clean healthy granulating surface.

Hemorrhage has never been observed in any of our series of cases; on the contrary, where the granulations have been disturbed we have frequently observed the immediate cessation of oozing upon the implantation of larvae. This observation has occurred with such frequency as to give thought to some definite excretory substance from the larvae having a very potent hemostatic effect in hemorrhage.

Complications from the use of larval therapy are very few. W. S. Baer recorded the possible introduction of B. tetani. Early in the development of our own work, before our methods of egg and larva sterilization were improved, we found one case which developed erysipelas during the period of treatment. Its source of origin was the wound and it is possible that the offending streptococcus may have entered with the larvae.

After reviewing our bacteriological study of the larvae, sterilized by our present method, we believe that there is only a remote possibility of virulent organisms entering wounds through the implantation of prepared larvae.

The soil and water forms and certain strains of staphylococcus and other organisms were found in cultures only after prolonged incubation, which further strengthens our belief that they are avirulent and essentially non-pathogenic.

Another complicating factor which occurred in three of our cases was the development of an urticaria during the period of implantation. The allergic reaction proved to be only of a mild nature.

An interesting feature in all of the cases was the absence of any reaction during the initial implantation, but following subsequent treatments there were observed many dead larvae in two of the wounds which were entirely clean and free of necrotic tissue. The question arose as to whether the presence of dead larvae played a role in the development of the allergy. We feel that this finding indicates the necessity for the immediate removal of dead larvae; and also, there may be an element of danger in permitting too long confinement of the living larvae in the wound.

As a matter of safety and in order to obtain a maximum activity, we follow a rule of implanting the larvae every third day, after the wound has been carefully cleansed with saline solution. The thorough removal of wound secretion, particularly when the granulations are healthy and abundant, also prevents the gummy serum from clogging the respiratory channels of the larvae, thus preventing asphyxiation. This factor offers an explanation of the death of so many larvae in the wounds at this period of healing.

Our present series constitutes a study of 56 cases. We have endeavored to observe the action of the larvae in all types of infection as well as the reaction upon diseased bone and especially soft tissues.

The results obtained in the treatment of osteomyelitis by larval therapy have been well pointed out by W. S. Baer and were found to be most gratifying as compared with other forms of therapy.

Our own results compare favorably with those of others. Twenty-eight cases of all types of osteomyelitis were treated: 4 cases represented the very acute hematogenous type; 6 cases represented the old chronic type of years' duration with multiple sinus tracts, in which the bony structure of the greater portion of the shaft had become thickened and ebonized, with multiple pus foci engaging the bony structure throughout. A third type, of which there are 18 cases, represented a milder form of shorter duration and with less bony involvement, following injury such as is found in compound fractures.

An analysis of our results in osteomyelitis with larval therapy shows excellent recoveries in the acute form. Following

operation which established wide open drainage to all foci of infection in the bone, the larval therapy was shortly instituted. It required only two, three, five and seven implantations in these 4 cases. This brought about complete elimination of the infection, while the wound showed a complete covering of the bony structures with healthy granulations. All wounds healed completely without recurrence and with an excellent return of function. These findings are most encouraging for larval therapy when instituted early in acute hematogenous osteomyelitis.

Our results in the second and most difficult type were not so encouraging. Many factors influence the extent of treatment. The patient as a rule represents a type of low vitality, as the result of absorption of toxic products from the diseased area over a long period. This factor limits the degree of surgery, when at the same time it is imperative to perform a complete gutter operation, exposing all foci cavities so they may be attacked by the larvae. This technique is not always possible for reasons already given, and one must resort to several-stage operations which of course prolong the convalescent period.

Six of our series represent typical cases of this variety. All were of many years duration. One required only eight implantations with complete recovery; another required fifty-one implantations with complete healing. This patient was far below par, showing a secondary anemia and a pyonephrosis. Three of this group have been under treatment for one year, requiring several operations for further drainage. All three infections are confined to the femur and at the present time the *x*-ray films show marked improvement, no sequestra and no further bony involvement. The wounds are not as yet completely healed but we feel their prognosis is good. The sixth patient of this group gave a history of nineteen years duration, (most of which period he was bed fast). The case was complicated by a marked secondary anemia and a family history of leucemia. At autopsy, in addition to other lesions a large cirrhotic liver and an enlarged spleen were found. The involvement was confined to the ilium of the right pelvis and entire shaft of the right femur. An extensive gutter operation upon the right femur was performed and the larvae implanted on the third day. Four implantations were made, and the elimination of infection and the development of granulations were so rapid as to fill the distal two-thirds of the shaft with granulations. Unfortunately the patient developed acute intestinal hemorrhages which did not respond to several transfusions, and died.

The third group comprises a series of 18 cases representing milder types resulting from trauma, frequently compound fractures with persistent sinus infections and with occasional involvement of the entire shaft. Larval therapy in this type we have found to be of great assistance, far superior to any other form of treatment. With open drainage the larvae will attack large devitalized sequestra and detach them from viable bone with but a few implantations. We also feel that bony union and callus formation take place at an earlier date due to the stimulation of an increased vascular supply to the site of fracture.

A great advantage was noted in the early treatment of compound fractures by larval therapy. After open reduction and fixation of the fragments with a bone plate, the wound is left open and packed with plain gauze. On the second day the packing is removed and larvae are implanted and this is repeated at intervals thereafter until the wound is covered by healthy granulations. Very satisfactory results have been obtained in this manner.

We have been interested to note the effect of larval therapy upon soft tissue infections of all types. We have found that no particular pyogenic organism repels the attack or delays activity of the larvae. We have observed that the activity of the

larvae on soft tissue including fascial structures is so rapid that healing takes place before marked invasion by organisms occurs and before further soft structures are destroyed.

Twenty-nine cases have been treated including a variety of pathogenic organisms, chief among which are: Streptococcus hemolyticus, staphylococcus, pneumococcus, B. tuberculosis, B. coli and B. welchii and others. Included in this group are felons, tuberculous inguinal adenitis, large areas of cellulitis, infected abdominal incisions following appendiceal abscess, infected amputation stumps, including also 6 cases of gas bacillus infection. The entire group except one made splendid recoveries with good return of function.

We have observed with great interest the effect of larval therapy upon acute gas bacillus infection, all of which responded without other forms of therapy except for the establishment of wide open drainage. All cases recovered with complete elimination of the organism except one. This patient, who was sixty-eight years of age, sustained a gas bacillus infection of an extensive leg wound with associated injuries of back, crushed chest and severe shock. The infection was entirely eliminated as shown by culture but the patient died ten days later as a result of pneumonia.

In a previous publication we referred to our early observations of larval therapy in gas bacillus infections, which, carried on at that time with grossly unsterile larvae, showed amazing results. Our recent findings confirm our early ones in that larval therapy, when used in this type of infection, is accompanied by excellent results with an early return of function.

Malignant tissue has shown a very weak defense against the activity of the larvae. Our observations have been rather limited to two inoperable ulcerating carcinomas of the breast and two sarcomas of the thigh. Upon admission each breast ulcer measured the approximate size of a half dollar with the malignant tissue presenting itself upon a level with the surrounding skin. There was extensive invasion of almost the entire breast substance. Following four implantations of larvae in one case there was observed an excavation of the underlying malignant tissues for a depth of 3.5 to 4 cm. but with only slight variation in the size of the original skin opening. As the larvae cleared away the malignant tissue, clean healthy granulations appeared, the odor disappeared, the pain was relieved and the wound attempted to close. This was prevented by self-retaining retractors so as to permit the larvae to attack the deeper malignant structures. The remaining cases showed a similar response. No attempt whatever is made to claim larval therapy as general cure for cancer but simply to note its reaction on abnormal and malignant growth.

We have not as yet expressed our views regarding the nature of the larval activity. We have noted, however, that the rapid liquefaction and removal of dead and necrotic tissue from a wound is far out of proportion to that accomplished by any known mechanical or chemical means. We are not convinced that it represents strictly a mechanical removal, but on the contrary are led to believe that certain potent (digestive) proteolytic enzymes secreted by the salivary and intestinal glands of the larvae produce a liquefaction of the devitalized tissues, thereby hastening its removal.

CONCLUSIONS

Considerable work must yet be done to place the therapy on a practical basis.

We suggest the name "Larval Therapy."

No detrimental effects or complications have developed from the use of larvae prepared by our present method of sterilization. We believe that the use of the iodine solution described is of great value.

The time element of implantation has been placed on a practical working basis.

We have encountered no opposition from our patients.

All our results compare favorably to any other form of treatment and in most instances are far superior.

Its value in the treatment of gas bacillus infection and other soft tissue infections is outstanding.

We have never observed any deleterious activity of the larvae upon normal viable human tissues.

The larva show an unusual activity against abnormal or malignant structures.

Aside from the scavenger action we feel the larvae produce a definite excretory proteolytic substance which hastens liquefaction of devitalized tissue.

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SELECTIVE THERAPEUTIC PNEUMOTHORAX IN ACUTE PULMONARY SUPPURATION

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MORE than a century ago Carson[1] pointed out on purely theoretical grounds that by collapsing the lung "the diseased part would be placed in a quiescent state and the divided surfaces would be brought into close contact, so that an abscess in this lung would be placed in circumstances at least as favorable to the healing process as the same affections on any other part of the body." That artificial pneumothorax is the most effective surgical measure for immobilization of the diseased lung is now a universally accepted fact, but that it is possible to compress the involved portion of the lung without curtailing much of the functional capacity of the same lung is not well known. This selective action of artificial pneumothorax in the treatment of pulmonary tuberculosis has been described by Morgan,[2] Gwerder,[3] Barlow and Kramer,[4] and the author.[5] Unfortunately such a selective pneumothorax can be applied only in a small number of cases of pulmonary tuberculosis, because by the time this chronic disease manifests itself clinically, the pathologic lesion is usually extensive and marked pleuritic adhesions prevail. However, in cases of acute pulmonary suppuration in which symptoms as a rule appear early in the course of the disease, when the pathologic lesion is still relatively small and plastic, a selective collapse could be instituted very frequently. Surprisingly, the numerous articles on collapse therapy in nontuberculous pulmonary suppuration make no mention of this selective phenomenon of artificial pneumothorax. It is the purpose of this article to explain the curative mechanism of this selective pneumothorax in acute pulmonary suppuration with the hope that its application may be considered early in the disease when it offers a maximum result with a minimum risk. Furthermore, such a selective collapse, if carried out properly, will disturb the intrathoracic equilibrium to only a slight extent, and cause very little discomfort to the patient.

MECHANISM OF SELECTIVE PNEUMOTHORAX

The presence of air in the pleural cavity does not necessarily keep the affected lung from participating in the respiratory function, and as long as the intrapleural pressure remains less than the intrapulmonary one, the collapsed lung will continue to expand and contract with each respiratory cycle. In a previous contribution,[6] I have indicated that at least three definite types of pneumothorax exist with reference to the functioning portion of the treated lung: (a) *expansile pneumothorax*, in which the intrathoracic pressure is lower than the intrapulmonary pressure, and the treated lung, recoiled by virtue of its own elasticity, still manifests definite, though limited, respiratory excursions; (b) *static pneumothorax*, or pneumothorax of rest, in which the intrapleural pressure equals that of the intrapulmonary, i.e., both are at atmospheric pressure, and the collapsed lung is in a state of equilibrium or rest; (c) *compression pneumothorax*, in which the intrapleural pressures exceed the atmospheric pressure, and the lung becomes actively compressed and its respiratory function reduced to a minimum.

The distribution of air in the pleural sac, on the other hand, is governed not only by the intrapleural pressure created, but also by the extent and location of the lesion, the stability of the mediastinum,

the presence or absence of adhesions, and above all, by the type of pathologic lesion and the degree of destruction of

Fig. 1. Suppuration on left lower lobe.

the elastic tissue. The elasticity of the functioning lung tissue manifests itself through its *expansile* and *contractile* force to about the same degree. Pathologic involvement of the lung may attenuate, injure or destroy entirely either the expansibility alone, the contractility alone or both of them simultaneously. In atelectasis, the expansile force of the pulmonary tissue is reduced and the contractile force is present. In emphysema, the reverse takes place; the contractility is attenuated whereas the expansibility is intact leading to an overinflation. When inflamed lung tissue goes through the gamut of destruction and repair to fibrosis, it becomes hard and unyielding, though it possesses an innate tendency to shrink slowly.

In the inflammatory condition of pneumonitis the expansibility is more impaired than contractility and there is a strong tendency for such lung tissue to undergo atelectasis. Consequently, the amount of gas in the pleural cavity which will only partially reduce the expansibility of the normal lung, will entirely inhibit the expansile power of the diseased part which has already been weakened by the pathologic changes. It is also to be remembered that diseased and edematous alveoli contain much less air than normal alveoli, and very little pressure is required to render such alveoli entirely airless and close them up completely, preventing their to-and-fro motion synchronous with the respiratory movements.

Making use of these biophysical laws of pneumodynamics, it is possible to have the air injected into the pleural cavity to localize mostly over the diseased area, provided no pleural adhesions are present and the lesion is soft and plastic. The illustrations exhibit this phenomenon very saliently.

Figure 1 is a roentgenogram of a case of pulmonary suppuration in the lower lobe of the left lung. Figures 2 and 3 are roentgenograms of the same case taken in inspiration and expiration respectively, after induction of left pneumothorax. The lower diseased portion is compressed into a solid mass and shows very little, if any, inspiratory expansion, whereas the upper undiseased portion expands and contracts with each respiratory cycle. Figure 4 is a roentgenogram of the same case taken a few weeks after the initiation of the therapy and reveals the pneumothorax localized in the form of a wedge of air splinting the diseased portion of the lung, allowing at the same time the non-diseased portion to expand almost to the periphery during inspiration.

The compression of the diseased alveolar tissue and the patency of the bronchi and bronchioles are graphically represented in Figure 5, a roentgenogram of the same case taken after the injection of lipiodol into the collapsed lower lobe; it discloses the bronchi as well as the minute bronchioles filled with lipiodol which failed to penetrate into the alveolar area compressed by the pneumothorax. Fluoroscopy in the postero-anterior and antero-posterior as well as in the oblique and lateral positions showed that the lipiodol pervaded all the various ramifications of the bronchial

tree of the lower lobe, but could not permeate the apneumatic portion of the same lobe even when the patient was made to cough forcibly. The effect of such an elective pneumothorax is at once evident; it leaves the bronchi open for drainage but keeps the diseased as well as the immediately adjacent alveoli deflated which not only prevents the spread of infection, but also augments healing by primary intention.

Fig. 2.

Fig. 3.

Figs. 2 and 3. Inspiratory and expiratory roentgenograms respectively of same case as Figure 1, after induction of 300 c.c. of air. Note that upper non-diseased portion of left lung expands and contracts with respiratory cycle, but compressed diseased portion shows very little respiratory change.

The intrathoracic, hemodynamic, and spirometric changes in pneumothorax have been discussed fully in previous contributions[7, 8]; suffice it to mention here that the selective type of pneumothorax throws little functional and mechanical strain on the healthy lung, entails almost no circulatory embarrassment, and effects only a negligible diminution in the vital capacity of the patient.

When there is a preponderance of fibrosis and the suppurative area becomes indurated and unyielding, or if adhesions have been formed, the phenomenon of selective pneumothorax can never be elicited. If a high tension pneumothorax is created in such a pleural cavity, it will succeed in deflating only healthy lung tissue, but will exert little compression on the diseased rigid portion of the same lung, thus defeating the main object of the collapse therapy. Figure 6 demonstrates this principle clearly. This roentgenogram was taken after a high tension pneumothorax was induced into the left hemithorax in a case of pulmonary suppuration of seven months' duration; it reveals an irregular outline of the compressed lung with many pockets of air in the pleural cavity separated by bands of adhesions, the mediastinal structures as well as the heart are displaced to the right, the diaphragm is forcibly pushed down, the volume of the healthy lung above and below the lesion is reduced to a third its anatomical size, whereas the diseased rigid portion is affected only

slightly by the presence of air. Such a pneumothorax is per se of little benefit to the patient; perhaps its only usefulness is in getting the patient gradually readjusted to changes in the intrathoracic pressures in order to avoid the sudden shock when the thorax has to be opened eventually for more radical surgery.

FIG. 4. Roentgenogram of same case as in Figures 2 and 3, about six weeks after initiation of pneumothorax. Note "wedge of air" splinting lower diseased portion, whereas healthy lung tissue expands almost to periphery.

FIG. 5. Roentgenogram of same case as Figure 4 after injection of 20 c.c. of lipiodol outlining all bronchi in compressed lower lobe.

TECHNIQUE

Much of the success of collapse therapy depends on the finesse of the technique not only at the initiation of pneumothorax, but even to a greater extent at the subsequent refills which are to be carried out throughout the entire course of the treatment. The needle to be used, the costal interspace of entry, the manometric readings, the amount of air to be insufflated each time, the intervals between the insufflations, the roentgenographic and fluoroscopic observations and interpretations, all have a bearing on the success or failure of the therapy.

The needle should be small in caliber, not larger than 20 or 22 gauge, but of the necessary length. The choice of the intercostal interspace through which the needle is to be introduced depends on the location of the lesion. The safest spot is about two interspaces above or below the site of the lesion as determined roentgenologically, and preferably at about the mid-axillary line, unless otherwise indicated. Needless to add, that the site of inoculation should be well anesthetized with novocaine previous to the insertion of the needle, and strict asepsis is to be adhered to throughout the operation.

The water manometer is to be watched carefully. No air should be administered unless free manometric oscillations were obtained and both the inspiratory and expiratory readings were negative; the only sure criterion that the needle is in the pleural space.

The amount of air to be introduced at one insufflation is never to exceed one-sixth of the vital capacity of the patient, or roughly 150 to 200 c.c. The intervals between insufflations vary during the course of collapse therapy; during the first two weeks it is advisable to reinflate

the pleural cavity every second or third day, but as we progress in the course of treatment the intervals are gradually increased, depending on the individual case. Close observation of the roentgenologic and spirometric changes are of great help in the regulation of the reinsufflations.

The patient is to be kept in bed only as long as there are constitutional symptoms, but the subsequent reinsufflations do not require confinement to bed. The patient may even be allowed to engage in gainful occupation while the treatment is continued. The collapse should be maintained at least three months after the abatement of all subjective symptoms.

DISCUSSION AND CLINICAL CONSIDERATIONS

Various operative procedures find their indications in the treatment of nontuberculous pulmonary suppuration according to the pathologic nature and the location of the disease. The more chronic the process, the more it becomes refractory to conservative treatment and demands radical surgery. On the other hand, there are cases of acute pulmonary suppuration which clear up spontaneously under ordinary medical regimen. However, if no clinical improvement has occurred in about four weeks after the onset of the disease, active surgical intervention is indicated, and artificial pneumothorax is the least radical and most effective therapy at that moment. Because of the pneumodynamic principles discussed previously, gas introduced into the pleural cavity can be made to localize mostly over the diseased portion of the lung, provided the lesion is still soft and yielding and no adhesions exist. Such a selective pneumothorax causes almost no discomfort, neither at the first induction of air nor at the subsequent refills, for the functioning pulmonary tissue is disturbed very little. The gas is administered not with the purpose of compressing the *entire* lung, but to keep the *diseased portion* alone at rest. The continuous compression of the diseased portion squeezes out gradually the infectious material, lessens the absorption and the dissemination of toxins, and enhances at the same time the reparative power favoring healing almost by primary intention.

Pneumothorax of the selective type, if properly managed, will seldom, if ever, tear adhesions and rarely cause an empyema. However, it should be emphasized that even the presence of an empyema is not a contraindication to pneumothorax. Dana[9] has reported excellent results in a group of cases of empyema treated by aspirating the pus and introducing air into the pleural cavity. This method of aspiration of fluid and replacement by air has long been employed in cases of tuberculous empyema, but Dana was the first to apply it in cases of acute empyema.

If the case has lapsed into the subacute or chronic stage, in which fibrosis and induration preponderate, or in cases of suppurative bronchiectasis with stiff walls, the selective phenomenon of artificial pneumothorax can never be elicited. The therapeutic value of pneumothorax in such cases is doubtful, inasmuch as the rigid diseased area will not yield to a collapse of a safe degree of tension. Still, even in such cases artificial pneumothorax finds its usefulness as a preliminary procedure to radical thoracic surgery, for it gradually readjusts the respiratory and circulatory systems to alterations in the intrathoracic pressure, and prevents the sudden shock incidental to free thoracotomies. Eloesser[10] has also indicated the advantages of preparatory pneumothorax in emptying the suppurating lung from secretions prior to operation, for "when it is used one no longer sees pus streaming from the patient's nose and mouth as it does when a suppurative lung is suddenly collapsed on the opening of the thorax."

This preparatory function of artificial pneumothorax in cases of chronic pulmonary suppuration should never be confused with its significant therapeutic action in cases of acute pulmonary suppuration.

In view of the newer understanding of the curative mechanism and effect of the selective action of artificial pneumothorax, it should be recognized as the surgical treatment of choice in early suppurative lesions, and its application should not be delayed. It not only augments the healing process, but offers a more speedy and much more complete functional recovery.

FIG. 6. Roentgenogram taken after induction of a high tension pneumothorax in a case of chronic pulmonary suppuration. Rigid suppurative area is affected very little by pneumothorax, only healthy lung tissue above and below is compressed. (Note also parodoxical movement of diaphragm.)

A diagnostic bronchoscopy should be performed in every case of pulmonary suppuration preceding the initiation of pneumothorax, inasmuch as a suppurative lesion may be secondary to neoplasm of a bronchus, and in such cases, collapse therapy would be futile.

CONCLUSION

The difference in the elasticity and consistency of the diseased and healthy lung tissue as well as the difference in the intrapulmonary and intrapleural pressures make it possible for the air introduced into the pleural cavity to localize over the diseased portion without curtailing much of the function of the non-diseased portion in the treated lung. This selective type of pneumothorax can be instituted only in recent cases of pulmonary suppuration when the lesion is soft and plastic, whereas in late stages of pulmonary suppuration the presence of marked fibrosis and pleural adhesions render such a pneumothorax inapplicable.

Every case of acute pulmonary suppuration should first be treated expectantly, but if no spontaneous cure has occurred within four weeks after the diagnosis has definitely been made, active surgical intervention is indicated, and pneumothorax of the selective type is the least radical and most effective therapy at that moment. A successful selective pneumothorax immobilizes the diseased portion without reducing the vital capacity, stimulates drainage, entails little respiratory and circulatory changes, and causes very little discomfort to the patient both at the initiation of the treatment as well as at the subsequent reinsufflations. The insufflatory amount should vary from 150 to 250 c.c., and the intervals from three to five days. As the patient improves the periods between insufflations are increased. The collapse should be maintained at least three months after the abatement of all subjective symptoms.

In cases of chronic pulmonary suppuration with indurated rigid lesions and pleuretic adhesions, the selective action of artificial pneumothorax can never be elicited. Pneumothorax is per se of little therapeutic value in such cases, though it still finds its use as a preparatory procedure to radical thoracic surgery.

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[For Remainder of References see p. 66.]

DIAGNOSTIC NOVOCAINE BLOCK FOLLOWED BY SYMPATHECTOMY FOR THE RELIEF OF AMPUTATION STUMP PAIN

REPORT OF CASE*

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PAINFUL stumps following amputation are notoriously difficult to desensitize; the same is true of causalgias and other obscure painful conditions which follow healing of penetrating wounds, prolonged infection, and trauma of the hands and feet. The pain in these cases is usually severe, of a burning or lancinating character, and often radiates from the lesion to affect half or the entire extremity. In many intractable cases, the pain is accompanied by a state of vasospasm with cyanosis, coldness and claminess of the area about the scar or even of the entire distal portion of the affected extremity. In these instances, the pain and vasospastic symptoms are usually relieved for the time when heat is applied, but are pronounced when the part is exposed to cold. The stump at times may be 10° to 25°F. colder than the opposite extremity, though the patient be sitting in a room at ordinary temperature.[1]

Repeated amputations with excision of neuromata and scar tissue often fail to give relief, and frequently only make matters worse; resection of the peripheral sensory nerve supply and even division of the posterior roots of all the spinal nerves to the extremity have been equally ineffectual. Any method, therefore, which will point out the nerve pathway transmitting both the vasomotor and the pain impulses, will at the same time show us directly the point for rational treatment for relief of symptoms.

Diagnostic novocaine block has been effectively used by White[2] to determine preoperatively the exact nerve pathways involved in transmitting the pain, and subsequent alcoholic injection or surgical excision of the nerve tissue has given highly gratifying clinical results. He has used the method in cases of angina pectoris, painful amputation stumps, aortic aneurysm, carcinoma of the lung and pleura, Raynaud's disease and in various trophic ulcerative conditions of the extremities. The novocaine block can be carried out

FIG. 1. Site of left paravertebral incision.

* Read before the Columbus Academy of Medicine, Nov. 23, 1931.

without risk to the patient and shows not only the site for subsequent treatment, but allows both the patient and the doctor to determine preoperatively the amount of objective and subjective improvement which can be expected through later operation.

The work of other investigators (Adson, Langley, Swetlow, Mixter, Mandl, White, Flothow and Woodbridge) has revealed the following pertinent facts concerning sensory and vasomotor pathways:[3]

1. Sensory fibers transmitting pain impulses from the heart, aortic arch and lungs leave the dorsal sympathetic chain to enter the cord through the upper five to six thoracic rami.

2. Cardiac pain confined to the left side can be abolished by alcoholic injections or surgical excision of the left stellate and second thoracic sympathetic ganglia and their branches.

3. Sensory fibers conducting pain from the viscera course through the splanchnic nerves to the ganglionated trunk which they leave to enter the cord in the following segments:

Esophagus	D 5 to D 6
Stomach	D 7 to D 8
Gall bladder	D10 (right)
Small intestine	D 9 to D10
Kidneys	D12 to L 1
Appendix	L 1 to L 2 (right)

4. Vasoconstrictor fibers to the lower extremities may be intercepted by bilateral lumbar sympathectomy.

5. Vasoconstrictor fibers to the arm do not come from the cord along with the roots of the nerves to the brachial plexus, but leave the cord from the fifth to the ninth dorsal segments, enter the dorsal sympathetic trunk through corresponding white rami communicantes, and rise to the upper two thoracic and lower cervical sympathetic ganglia; here they leave as postganglionic fibers through the gray rami to enter the trunks of the brachial plexus. (It may be said also that clinical evidence obtained following division of the posterior roots of all the nerves of the brachial plexus, and excision of the stellate and second thoracic sympathetic ganglia, would indicate that certain important pain fibers from the upper extremity reach the cord by following a quite similar course.)

The following is a case in point:

History: A white man, aged forty-eight, first came to us April 23, 1931 with a history of having crushed his left hand beneath a steel beam October 25, 1928. The fingers and distal part of the palm were badly lacerated, and emergency treatment included amputation of the left middle finger. In the following January (1929) the left index finger was amputated because it was stiff and painful. These amputations were just distal to the bases of the proximal phalanges. In December, 1929, the left ring and little fingers were amputated at the metacarpophalangeal joints because they were useless, painful and stiff.

Pain, aching and tenderness have been present in the scar tissue of the left hand since the accident, the pain extending into the palm, and when more severe, radiating into the left forearm and elbow. There has been a cold and numb sensation in the left hand since healing of the laceration in 1928. The pain is always accentuated when the hand is exposed to cold, but can be much relieved, for the time at least, by the heat lamp or by soaking in hot water. Although the left thumb escaped injury, its motions have been restricted because of pain in the hand, and any attempts to use the stump cause it to jerk involuntarily and increase the pain. The patient has frequently been awakened at night by an onset of jerking and pain in the left forearm and hand.

When we first saw him in April, 1931, he was complaining of nearly constant pain in the stumps of the middle and index fingers, which had been previously amputated just distal to the metacarpophalangeal joints. These joints were not functioning, and the skin over the stumps was cyanotic and firmly attached by dense, tender scar tissue to the underlying uneven bone.

We were hopeful that an amputation behind the heads of the index and middle finger metacarpals would relieve the pain. On May 19, 1931 the stumps along with the adherent scar tissue were removed by Dr. Schwarzell. The wound healed nicely without undue scar

formation, but within the following weeks, the patient again complained bitterly of tenderness in his scar, and of pain in the left palm radiating and causes him to be very guarded in the use of his hand.

On August 22, 1931, Dr. Schwarzell injected

Fig. 2.

Fig. 3.

Figs. 2 and 3. Two months after operation; full motion of thumb possible without pain; no tenderness in stump.

Fig. 4.

Fig. 5.

Figs. 4 and 5. Two months after sympathetic ramisectomy and ganglionectomy; able to grasp firmly between thumb and palm without jerking or pain.

into the forearm. Involuntary jerking of the left hand and forearm again appeared with each attempt to use the stump.

Physical examination on readmission to Grant Hospital August 19, 1931 shows a fairly well-nourished middle-aged white man. All four fingers of the left hand have been amputated. The left thumb is perfectly normal, but during attempts to grasp between the palm and thumb, there is a gross involuntary jerking in the palm, wrist and forearm. There is a well-healed curvilinear incision along the distal end of the stump, but no exuberant scar tissue. The distal part of the palm is cyanotic, especially in the region of the incision. The palm is tender to pressure and is hypersensitive even to light touch distally. The left hand is considerably colder than the palm and the fingers of the right hand, and is particularly cold at its distal extremity.

Observations during the next few days showed that the stump was cold, cyanotic and painful most of the time, which could be relieved by the use of heat. The patient noticed that the pain was most severe when the extremity was cold and blue, and though most intense in the stump, it would radiate up into the forearm. The man's prolonged suffering has made him noticeably nervous and haggard,

the left stellate and second dorsal sympathetic ganglia with 2 per cent novocaine. The record of the procedure is as follows: Advancing with 1 per cent novocaine, the needle was inserted 1¾ inches to the left of the tip of the first dorsal spinous process and directed forwards until the point was upon the first rib. The needle was then slightly withdrawn, directed medially along the under margin of the first rib and then between the posterior ends of the first and second ribs, where it was advanced ¼ inch forwards. When the needle came in contact with the stellate ganglion, tingling was felt in the left hand and 2 c.c. of 2 per cent novocaine were then injected. In a similar manner the needle was placed between the heads of the second and third ribs on the left, and the second dorsal sympathetic ganglion injected with 2 c.c. of 2 per cent novocaine.

Numbness appeared in the left hand and the pain was abolished immediately. The stump became pink and warm in a few minutes, and could be used in grasping without pain or jerking. The sensation of numbness disappeared about one hour after the injection; but pain, cyanosis and involuntary jerking did not return for twenty-four hours. The patient was pleased with the results of injection and was willing to undergo operation for permanent relief.

Operation: On September 2, 1931 under gas-ether anesthesia a vertical incision to left of midline from fifth cervical to third thoracic spines was carried down to the transverse processes. Muscle was dissected loose and retracted medially and laterally. The first and second thoracic transverse processes were resected. The pleura was bluntly dissected from the endothoracic fascia, and about 1½ inches of the posterior ends of the first and second ribs were removed.

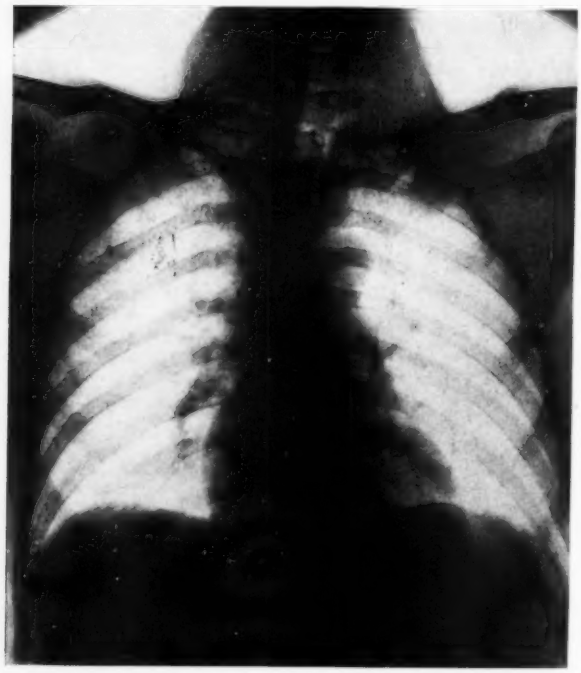

FIG. 6. X-ray taken postoperatively, showing resected portions of left first and second ribs and corresponding thoracic transverse processes.

Bleeding was carefully controlled by suture and ligation. The areolar tissue was then dissected away from the sympathetic trunk and from the first thoracic and eighth cervical nerves. The sympathetic trunk was severed below the second thoracic and above the inferior cervical ganglion; the intervening sympathetic trunk and ganglia were removed. (In this case the inferior cervical and first thoracic were fused to form a stellate ganglion.) All rami communicantes connecting these ganglia with the brachial plexus were removed along with a small branch running to this plexus medial to the main sympathetic trunk. The wound was then closed with interrupted chromic catgut in muscle and fascia, and a running catgut suture in the skin. Plain gauze was used for drainage.

Upon returning from the operating room, the patient showed a pulse ranging from 100 to 120. Temperature reached 100°F. the same evening, and dropped to 99.2°F. the next morning. Except for a moderate wound infection, convalescence was uneventful. The chief postoperative complaint was pain in the upper left chest and precordium during deep inspiration. This symptom, appearing at intervals for about a week, was apparently due to pleural irritation at the left apex.

X-ray of the chest made November 9, by Dr. Hugh Baldwin shows both lungs fully expanded, and shows the resected portions of the left first and second ribs and corresponding transverse processes.

Immediately following the operation, there developed a pronounced constriction of the left pupil; and though not quite so marked, Horner's syndrome is still present on the left side. Since the operation there has been no return of pain, cyanosis or jerking in the left hand or forearm; and the stump has been pink and warm, usually warmer than the opposite hand.

SUMMARY

1. The development of vasospastic symptoms, tenderness and persistent pain in and adjoining the scar following certain injuries or amputations is discussed.

2. Some facts of practical significance concerning pain and vasomotor pathways through the sympathetic system, are reviewed and tabulated.

3. We have reported a case of a hand injury accompanied by severe pain and vasospastic symptoms which were unrelieved by repeated amputations, but which were immediately and completely abolished by sympathectomy.

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ANESTHESIAS ADMINISTERED IN THE HOSPITALS OF THE STATE OF NEW JERSEY*

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SOME months ago, Dr. Gaston Labat, President of the American Society of Regional Anesthesia, appointed a committee to make an analysis of anesthesias administered in the hospitals in the State of New Jersey. This Committee prepared a questionnaire which was distributed to both private and public hospitals located throughout the State. The report which follows has been developed from the answers obtained as a result of this canvass. It includes information relative to the various types of general and regional anesthesias in use, the person responsible for their administration, and the resultant deaths incurred. The data presented in this survey are for the year 1930.

QUESTIONNAIRE

1. Is a physician anesthetist in charge of the department?
2. Are internes instructed in anesthesia?
3. Are there any nurse anesthetists employed?

A. *General Anesthesia:*

Number of General Anesthesias Administered in 1930	Type	Administered by			No. of Deaths	
		Attending	Interne	Nurse	Immediate	Remote
	a.					
	b.					
	c.					
	d					
	e.					
	f.					
	g.					
	h.					
	Total					

a. Ether
b. Gas oxygen
c. Gas oxygen ether
d. Ethylene
e. Avertin
f. Sodium amytal
g. Rectal
h. Miscellaneous: such as: chloroform, anesthol, alcohol-chloroform-ether, etc.

In Case of Death:
Remarks by anesthetist:

B. *Regional Anesthesia:*

A. *Spinal Anesthesia:*
1. Neocaine
2. Spinocaine
3. Supercaine
4. Nupercaine
5. Miscellaneous drugs, such as stovaine, etc.

B. *Other Methods of Regional Anesthesia:*
1. Nerve block
2. Field block
3. Sacral block
4. Miscellaneous.

Number of Regional Anesthesias Administered in 1930	Type	Administered by			No. of Deaths	
		Attending Anesthetist	Surgeon or Assistant	Interne	Immediate	Remote
	A.1					
	A.2					
	A.3					
	A.4					
	A.5					
	B.1					
	B.2					
	B.3					
	B.4					
	Total					

* Read before the American Society of Regional Anesthesia, N. Y. Academy of Medicine, Dec. 8, 1931.

1. *In Case of Death:*
   1. Dose of drug used
   2. Height of anesthesia
   3. Time of death after injection
   4. Remarks about case (anesthetist).
2. Does a competent person remain at head of patient during anesthesia? Doctor? Or Nurse?

It is interesting to note that although 85 questionnaires were distributed, only 23 were filled out and returned. One of these, however, had to be eliminated from the study, owing to the incompleteness of the information furnished. Of the hospitals returning the questionnaires 87 per cent have been approved by the American College of Surgeons, while 13 per cent have not been approved.

It is to be regretted that from one of the principal counties in New Jersey, a county in which all of the hospitals have been approved by the American College of Surgeons, not a single institution, after receiving repeated requests, returned the questionnaires. Is this due to carelessness, or disinterestedness, or are the records in this connection such that too much labor would be entailed to compile the data, or are the data available at all?

To the first query put forth in the questionnaire: "Is a physician anesthetist in charge of the department?," 68.42 per cent of the approved and 66.66 per cent of the unapproved hospitals answered in the affirmative. These figures may, however, be slightly inaccurate since one hospital, although admitting having a physician anesthetist in charge, in its questionnaire further indicated that all anesthesias were administered by nurses. In other words, the Chief Physician Anesthetist was merely a figure-head in this instance. Similar conditions may exist and probably do exist in other hospitals. Another institution responded that although it had an anesthetist in charge, some surgeons preferred to use their own nurses especially trained in this work.

The second question pertaining to the instruction of internes in the administration of anesthesias disclosed the fact that only 50 per cent of the hospitals furnished such instruction; classified according to type, 66⅔ per cent were unapproved hospitals and 47.369 per cent approved. Is this not a small percentage of approved hospitals wherein instruction of this kind is offered to internes?

As regards the third question: "Are any nurse anesthetists employed?," 59 per cent of the hospitals answered "yes"; of these 92 per cent were approved and 8 per cent unapproved. Without any statistics on hand to prove the contention, it is a well-known fact that nurses, as anesthetists, are on the increase. Is this due to the fact that women are by nature better adapted in the art of anesthesia than men, or is it because the physician administers anesthesias only as a stepping stone to surgery or some other specialty and does not intend to continue as an anesthetist when he has reached his goal; or, can it be for economical reasons which increase the income of the institution as well as that of the surgeon?

GENERAL ANESTHESIAS

A review of Table 1, which follows, shows that the nurses not only administer more general anesthesias than internes but also more than attending anesthetists.

TABLE 1
GENERAL ANESTHESIAS ADMINISTERED DURING 1930 IN 22 NEW JERSEY HOSPITALS

Administered by	Number of Anesthesias Administered	Per Cent of Total	Number of Deaths	Death Rate (Per Cent)
Attending anesthetist..	12,177	31.158	4	.000328
Interne anesthetist.....	11,203	28.666	13	.001160
Nurse anesthetist.....	15,701	40.175	7	.000445
Total.....	39,081	.....	24	.000614

It will also be noted from Table 1 that the anesthesias reported were administered in the following ratio: nurse anesthetists, 40.175 per cent; attending anesthetists,

31.158 per cent; interne anesthetists, 28.666 per cent. Considering the death rate, it will be seen that that of the nurse anesthetist is 35.67 per cent greater than that of the attending anesthetist, while the interne's death rate is 253.65 per cent greater than that of the attending anesthetist.

TABLE II

GENERAL ANESTHESIAS CLASSIFIED AS TO TYPE

Types of Anesthesia	Number of Anesthesias Administered	Per Cent of Total	Number of Deaths	Death Rate (Per Cent)
a. Ether	12,447	31.8492	14	.001124
b. Gas oxygen	6,778	17.3434	3	.000442
c. Gas oxygen-ether	17,093	43.7373	6	.000351
d. Ethylene	1,666	4.2629	..	None
e. Avertin	239	.6115	1	.004184
f. Sodium amytal	50	.1279	..	None
g. Rectal	32	.0818	..	None
h. Miscellaneous	776	1.9856	..	None
Total	39,081	.....	24	.000614

An examination of Table II reveals the popularity of the general anesthesias used, in the order: gas oxygen ether, which is the most frequently used, then ether, gas oxygen, ethylene, miscellaneous, avertin, sodium amytal, and ending with rectal anesthesia, which is more rarely administered. This table also indicates that the death rate ranges from nil to 0.001124 per cent, in the following order: ethylene, 0; sodium amytal, 0; rectal, 0; miscellaneous, 0; gas oxygen ether, 0.000351 per cent; gas oxygen, 0.000552 per cent; ether, 0.001124 per cent, which has the highest mortality.

A consideration of Tables III, IV, and V discloses for all practical purposes that: firstly, the nurse anesthetist gives the greatest number of anesthesias, except where avertin, sodium amytal, and rectal anesthesias are employed (the attending anesthetist exceeds in this group, which as will be noted from the tables comprises the anesthesias most seldom used); secondly, the attending anesthetist has the lowest mortality; thirdly, although the interne anesthetist gives the least number of anesthesias, he has the highest mortality, ether is the anesthesia of which he usually makes use.

As regards the administration of general anesthesia, the trained physician anesthetist should be used in preference

TABLE III

GENERAL ANESTHESIA ADMINISTERED BY THE ATTENDING ANESTHETIST

Type of Anesthesia	Number of Anesthesias Administered	*Per Cent of Total by Types	Number of Deaths	Death Rate (Per Cent)
a. Ether	2,131	17.12	..	0
b. Gas oxygen	2,360	34.82	1	.000423
c. Gas oxygen ether	6,689	39.13	2	.000298
d. Ethylene	396	23.76	..	0
e. Avertin	204	85.35	1	.004901
f. Sodium amytal	35	70.00	..	0
g. Rectal	24	75.00	..	0
h. Miscellaneous	338	43.55	..	0
Total	12,177	31.15 All types	4	.000328

* Per cent of total of each type of anesthesia administered by attending anesthetists, internes and nurses.

TABLE IV

GENERAL ANESTHESIA ADMINISTERED BY THE INTERNE ANESTHETIST

Type of Anesthesia	Number of Anesthesias Administered	Per Cent of Total by Types	Number of Deaths	Death Rate (Per Cent)
a. Ether	5,897	47.37	11	.001865
b. Gas oxygen	1,523	22.46	2	.001313
c. Gas oxygen ether	3,463	20.25	..	0
d. Ethylene	120	7.202	..	0
e. Avertin	24	10.0418	..	0
f. Sodium amytal	15	30.00	..	0
g. Rectal	2	6.25	..	0
h. Miscellaneous	159	20.48	..	0
Total	11,203	All types 28.66	13	.001160

TABLE V

GENERAL ANESTHESIA ADMINISTERED BY THE NURSE ANESTHETIST

Type of Anesthesia	Number of Anesthesias Administered	Per Cent of Total by Types	Number of Deaths	Death Rate (Per Cent)
a. Ether	4,419	35.50	3	.000678
b. Gas oxygen	2,895	42.71	..	0
c. Gas oxygen ether	6,941	40.60	4	.000576
d. Ethylene	1,150	69.02	..	0
e. Avertin	11	4.60	..	0
f. Sodium amytal	.....	0	..	0
g. Rectal	6	18.75	..	0
h. Miscellaneous	279	35.95	..	0
Total	15,701	All types 40.17	7	.000445

to all others, or in the event that this cannot be done, it is better to advocate the use of the nurse anesthetist, rather than the interne anesthetist.

REGIONAL ANESTHESIAS

As regards regional anesthesias, it was reported that for 10,758 administered, there was a mortality of 14, giving a death rate of 0.00130 per cent. Of this number the attending anesthetist gave 3069, or 28.5276 per cent, with a mortality of 7, making a death rate of 0.00228 per cent; the attending surgeon gave 7020, or 65.2537 per cent, with a mortality of 7, and a death rate of 0.000997 per cent; the interne anesthetist gave 669 anesthesias, or 6.2186 per cent, with no mortality.

TABLE VI

REGIONAL ANESTHESIAS—ALL TYPES ADMINISTERED DURING 1930 IN 22 NEW JERSEY HOSPITALS

Administered by	Number of Anesthesias Administered	Per Cent of Total	Number of Deaths	Death Rate (Per Cent)
Attending anesthetist	3,069	28.5276	7	.00228
Surgeon anesthetist	7,020	65.2537	7	.000997
Interne anesthetist	669	6.2186	..	0
Total	10,758	.....	14	.00130

It will be seen from Table VI that the anesthesias administered were in the following ratio: surgeon anesthetists, 65,2537 per cent; attending anesthetists, 28.5276 per cent; interne anesthetists, 6.2185 per cent. This table also indicates that the surgeon anesthetist has a lower mortality than the attending anesthetist, and the interne anesthetist no mortality.

A comparison of general anesthesias with regional anesthesias as brought out in Table VII reveals that of the two groups general anesthesias are more frequently used, or in 78.414 per cent of the cases, while regional anesthesias are employed in 21.585 per cent of the cases. The mortality rate for general anesthesias is 0.000687 per cent or 52.8055 per cent lower than that for regional anesthesia.

TABLE VII

GENERAL AS COMPARED WITH REGIONAL ANESTHESIAS

Type of Anesthesia	Number of Anesthesias Administered	Per Cent of Total	Number of Deaths	Death Rate (Per Cent)
General anesthesias	39,081	71.414	24	.000614
Regional anesthesias, all types	10,758	21.585	14	.001301
Total	49,839	.....	38	.000762

Table VIII illustrates the frequency of use of the various kinds of regional anesthesia employed. They may be listed as follows, according to their popularity:

1. Nerve block
2. Spinal neocaine[1]
3. Field block
4. Spinal spinocaine
5. Miscellaneous (b)
6. Sacral block
7. Miscellaneous spinal
8. Nupercaine
9. Supercaine

It should be mentioned, however, that although nerve block heads the list as the anesthesia in this group most often administered, it is in this position merely because practically all of those reported were given by one hospital. Table VIII

TABLE VIII

REGIONAL ANESTHESIA ADMINISTERED BY ATTENDING SURGEON AND INTERNE ANESTHETIST

Type of Anesthesia	Number of Anesthesias Administered	Per Cent of Total	Number of Deaths	Death Rate (Per Cent)
A. *Spinal Anesthesia*				
1. Neocaine	2,683	24.939	11	.004099
2. Spinocaine	1,564	14.538	3	.001918
3. Supercaine	27	.250	..	0
4. Nupercaine	40	.371	..	0
5. Miscellaneous drugs, such as stovaine, etc	46	.427	..	0
B. *Other Methods*				
1. Nerve block	2,840	26.398	..	0
2. Field block	2,112	19.632	..	0
3. Sacral block	591	5.493	..	0
4. Miscellaneous	855	7.947	..	0
Total	10,758	.....	14	.001301

[1] When the term neocaine is used it means novocaine, as there was very little neocaine used. Neocaine and novocaine are used as one.

also indicates that the death rate ranges from nil to 0.004099 per cent, in the following order: nerve block, 0; field block, 0; miscellaneous (b), 0; sacral block, 0; nupercaine, 0; supercaine, 0; spinocaine, 0.001918 per cent; neocaine, .004099 per cent, which has the highest mortality. In considering regional anesthesias, there is no doubt but that the mortality rate for this group would be greatly reduced if nerve and field block were administered in preference to spinal anesthesias.

TABLE IX
REGIONAL ANESTHESIA
ADMINISTERED BY THE SURGEON ANESTHETIST

Type of Anesthesia	Number of Anesthesias Administered	Per Cent of Total by Types	Number of Deaths	Death Rate (Per Cent)
A. *Spinal Anesthesia*				
1. Neocaine	564	21.0216	4	.007092
2. Spinocaine	926	59.2071	3	.003239
3. Supercaine	16	59.2592	..	0
4. Nupercaine	....	.....	..	0
5. Miscellaneous drugs, such as stovaine, etc.	41	89.1304	..	0
B. *Other Methods*				
1. Nerve block	2790	98.239	..	0
2. Field block	1966	93.0871	..	0
3. Sacral block	8	1.3536	..	0
4. Miscellaneous	709	82.9339	..	0
Total	7020	All types 65.2537	7	.000997

TABLE X
REGIONAL ANESTHESIA
ADMINISTERED BY THE ATTENDING ANESTHETIST

Type of Anesthesias	Number of Anesthesias Administered	Per Cent of Total by Type	Number of Deaths	Death Rate (Per Cent)
A. *Spinal Anesthesia*				
1. Neocaine	1748	65.1509	7	.004004
2. Spinocaine	575	36.7640	..	0
3. Supercaine	11	40.7407	..	0
4. Nupercaine	40	100.00	..	0
5. Miscellaneous drugs, such as stovaine, etc.	5	10.8695	..	0
B. *Other Methods*				
1. Nerve block	15	.5281	..	0
2. Field block	96	4.5454	..	0
3. Sacral block	579	97.9695	..	0
4. Miscellaneous				
Total	3069	All types 28.5276	..	.002280

A study of Tables IX, X and XI shows that the attending anesthetist administers the most spinal anesthesias, while the surgeon anesthetist gives the most nerve and field blocks.

TABLE XI
REGIONAL ANESTHESIA
ADMINISTERED BY THE INTERNE ANESTHETIST

Type of Anesthesia	Number of Anesthesias Administered	Per Cent of Total by Type	Number of Deaths	Death Rate (Per Cent)
A. *Spinal Anesthesia*				
1. Neocaine	371	13.8274	..	0
2. Spinocaine	63	4.0281	..	0
3. Supercaine				
4. Nupercaine				
5. Miscellaneous drugs, such as stovaine, etc.				
B. *Other Methods*				
1. Nerve block	35	1.2323	..	0
2. Field block	50	2.3674	..	0
3. Sacral block	4	.6768	..	0
4. Miscellaneous	146	17.0760	..	0
Total	669	All types 6.2186	..	0

The question of remote deaths will have to be disregarded at this time, as only one institution furnished any information in this connection. As to the question of immediate deaths: while under general anesthesia, the fatalities listed were incurred in connection with operations for appendicitis with peritonitis, thyroidectomy, tracheotomy, intestinal obstruction, sarcoma of femur, etc. In reporting the cause of death in these instances the terms cardiac dilatation, status lymphaticus, embolus, moribund, enlarged thymus, surgical shock, toxic, were used. As regards the mortality rate for regional anesthesia: the conditions for which the patients were operated upon were not indicated. The dosage for spinal anesthesia ranged from 110 mg. to 240 mg. The injections were given between the first and fourth lumbar vertebrae and death took place within ten to forty-four minutes.

As to the question: "Does a competent person remain at the head of the patient during anesthesia? Doctor? Or Nurse?," the answers were in the affirmative in all instances. The nurse remains at the head

of the patient in 59.05 per cent of the cases and the doctor, 40.95 per cent. However, this percentage does not give an accurate picture, for where the surgeon acts as his own anesthetist, as when regional anesthesias are employed, the nurse remains at the head of the table.

SUMMARY AND CONCLUSIONS

1. More complete and accessible anesthesia records should be kept.

2. Only 67½ per cent of the hospitals have a physician anesthetist in charge. A physician anesthetist should be in charge of the department regardless of whether nurse anesthetists are employed or not. He should have complete charge of this department with the same rights and authority as heads of other departments, and not act merely as a figure-head.

3. Only 50 per cent of the hospitals give instructions to internes. Provision should be made to give such instructions in all hospitals.

4. Fifty-nine per cent of the hospitals employ nurse anesthetists. There is a large field here for competent male anesthetists. More physicians should undertake this specialty.

5. Nurse anesthetists administer the largest number of general anesthesias.

6. The physician anesthetist has the lowest mortality.

7. The nurse anesthetist's mortality is 35.67 per cent greater than that of the physician anesthetist.

8. The interne anesthetist has the greatest mortality, 253.658 per cent greater than the trained physician anesthetist.

9. For the welfare of the patient, more trained physician anesthetists should be employed. If a physician, so trained, is not available for the administration of the anesthesia, it would be to the best interest of the patient to use the trained nurse anesthetist rather than the interne. The interne anesthetist should not be permitted to give anesthesias unless especially trained.

10. General anesthesias are more frequently used than regional anesthesias; or, in 78.414 per cent of the cases.

11. General anesthesias have a lower mortality rate than regional anesthesias; 52.8055 per cent lower.

12. Spinal neocaine is actually the most frequently used anesthesia in the regional group, while gas oxygen ether is in the general anesthesia class.

13. Spinal neocaine has a 1067.80 per cent, or more than ten and a half times greater mortality than gas oxygen ether, which proves that spinal neocaine should not be indiscriminately administered. If more use were made of nerve and field block, the mortality rate for regional anesthesias would drop.

14. There is a big field for the regional anesthetist. No doubt, if more physicians were to undertake this as a specialty, the surgeon anesthetist, who now gives most of these anesthesias himself, would be relieved of this burden, with the result that the mortality rate from anesthesias would be likely to decrease considerably. It is also quite likely that regional anesthesias would be more frequently resorted to, if specialists were available for this purpose.

15. Only 40.95 per cent of the hospitals have a physician at the head of the patient. While regional anesthesias are being given, a physician anesthetist should be at the head of the table, rather than a nurse or interne. In fact, the ideal situation would be one in which a well-trained physician anesthetist should give all anesthesias, both general and regional.

DISCUSSION*

Dr. Bortone (*closing*): The criticism presented by Dr. Livingston is just, that it is unfair to compare the percentages of 40 cases, or 10, or 12 cases with thousands of cases. It is also true that a wrong impression would be created, that spinal anesthesia is a safe anesthesia in the interne's hands, for he has no mortality, while the attending and surgeon anesthetists have. However, there are many factors that should be considered. Probably

* For Dr. Livingston's remarks see p. 67.

the interne did not handle the cases that were really serious, but only ordinary cases to which he administered spinal anesthesia, while the attending anesthetist, no doubt, handled the more hazardous cases—poor risks.

Statistics cannot be compared without a study of the tables. That is why I included them in this paper, so that in glancing over them the correct impression would be given, and it could be readily seen that there are relatively few cases in which avertin, sodium amytal, etc., were used and with no deaths. It naturally would be unfair to compare this small number with thousands of cases where there are no deaths.

There is another wrong impression that went forth and it is my fault: that neocaine spinal anesthesia has the highest mortality. This is not true, the blame is not on the drug neocaine itself. Under the caption neocaine, novocaine is included, and there are more spinal novocaine than spinal neocaine anesthesias, with no difference in mortality. The two are combined, using them synonymously. The impression that neocaine is the chief cause of death under spinal anesthesias is absolutely wrong. *It is the spinal anesthesia itself which is hazardous.*

That which has been most strongly suggested to me in this report is the fact that this Society should go on record, in advocating the preparation of a definite chart for the tabulation of regional anesthesia as administered, so that complete records can be obtained at any time. It is a fact that in most institutions today these records are kept very inaccurately. Usually only the dosage of the drug is recorded. The height of the anesthesia is not indicated, neither is any reference made to details such as the use of ephedrin and preoperative drugs, time of administration, blood pressure, pulse during administration, site of injection, method used (as to sabotage, amount of spinal fluid withdrawn), the preoperative condition of the patient, and so on.

I blame a good many of these deaths upon the anesthetist himself. I feel that anesthetists are responsible in this respect. There should be a Department of Anesthesia, and there should be not only one anesthetist in an institution, but an anesthetist in charge, with an assisting staff. In hospitals there are ordinarily five or six surgeons and but one anesthetist. Very often the anesthetist cannot be obtained at the hour he is needed. Therefore, the interne is resorted to or the regional anesthesia administered by the surgeon himself. In emergencies occurring during the night the anesthetist cannot always be located. Therefore, the interne is used on poor risks, which in itself is a detriment.

Better results could, no doubt, be obtained if the anesthetist would organize his department and have two or three assistants, so that when he is either not available, or when there are two or three cases at one time, his assistants may be employed. Perhaps the failure to organize such a Department of Anesthesia up to this time may be attributed to the selfishness of those anesthetists who desire to monopolize all this type of work. I believe that if the anesthetist would have two or three trained assistants, the nurse anesthetist would be eliminated more or less. However, the specially trained nurse anesthetist is a good anesthetist.

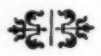
In summing up, the anesthetist should organize his department. Furthermore, he should have the say as to the type of anesthesia to be used and the surgeon should not have to dictate to him in this respect. I am sure that this would be the case if anesthetists were more competent. Anesthetists should demand their rights in institutions and should not be dominated by the surgeons and treated merely as technicians.

Under spinal anesthesia the death rate is high. It should not be. I would not want to give up spinal anesthesia. I use it frequently, but it should be used with discretion. What I mean by that is this: a man who makes use of spinal anesthesia as a routine in every case, without any discrimination, has a high death rate, and as a result condemns spinal anesthesia. Spinal anesthesia is often used foolishly. In cases of shock or moribund patients coming right from the street, spinal anesthesia should not be used. However, if the anesthetist does employ it, the death should be attributed to the poor judgment of the anesthetist in selecting spinal anesthesia, and not blamed upon the spinal anesthesia itself. Neither can spinal anesthesia be administered in a case of hemorrhage with shock. Neither would it be wise to use spinal anesthesia in cases such as carcinoma of the esophagus or stomach with malnutrition and dehydration. A gastrostomy or any other procedure can be done under regional infiltra-

tion or nerve and field block, but on the other hand, if spinal anesthesia were employed for such cases a high death rate would probably result.

If spinal anesthesia were used with discretion, mortality would be lowered. There are a few cases of spinal over which there is no control. In moribund patients, spinal anesthesia should not be used. In cases of auricular fibrillation, I use straight open ether, or field and nerve block. Some men have the idea that spinal anesthesia is to be used only on poor risks. The most important thing to be remembered with regard to the use of spinal anesthesia, and one of the reasons I would never want to relinquish it, is that it really lowers the operative mortality. It is an intangible thing. It makes a difficult operation easier and quicker. Under its use, tissues need not be mauled or packs used. There is a beautiful relaxation under which to work. Spinal anesthesia, so employed, lowers the operative mortality. It is hard to measure, but it is so. That is my clinical impression.

As I have said, spinal anesthesia, used properly, should not have the mortality this report indicates. I do not believe the statistics for this State are different from those in any other state. If groups of individual statistics, compiled by men who are interested in spinal anesthesia and competent anesthetists, were to be considered, I believe that the mortality would be found to be lower. Nevertheless, should they be studied as a group, good, bad and indifferent, statistics similar to those presented here would be noted, I believe, in any state selected at random. Individual statistics would show a lower mortality. If regional anesthesia, that is, field and nerve block, were more frequently administered, the resultant mortality would be lower.



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* Continued from p. 54.

CRITICAL REVIEW OF SURVEY:

ANESTHESIAS ADMINISTERED IN THE HOSPITALS OF THE STATE OF NEW JERSEY*

EDWARD M. LIVINGSTON, M.D.

NEW YORK CITY

THE study of Dr. Bortone and his committee on anesthesias administered in the hospitals of the State of New Jersey during 1930 represents, I am convinced, the most important group study presented before the American Society of Regional Anesthesia during the ten year period of its existence.

The major conclusions and recommendations of the report are clear-cut:

1. Departments of Anesthesia in all hospitals should be headed by specialists —trained physician anesthetists.

2. Rules regarding the administration of anesthetics should be explicit and exacting.

3. The untrained interne anesthetist constitutes a serious menace to life. Interne anesthetists as a class have an anesthetic mortality rate which is 253 per cent greater than that of the trained physician anesthetist.

4. Due recognition should be given to the importance of the specialty of anethesia and surgeons should cooperate to the utmost in the development of departments of anesthesia headed by trained physician anesthetists having rights and authorities consistent with their importance to the welfare of the patient. At present only 40 per cent of hospitals have a trained physician anesthetist at the head of the patient during the anesthetic phase of the operative ordeal.

Direct and effective action should be taken from some quarter to remedy abuses exposed in this report. The survey indicates a steady and certain life toll from the administration of anesthetics and makes clear that human life is being trifled with in any institution in which the anesthetic department falls below adequate standards.

The certainty of some corrective action rests with our ability to give this report the thought and emphasis which its results warrant. Dr. Bortone and his committee have rendered our Society a real service in their preparation of this detailed and careful study; and our Society, in turn, has an opportunity for service in seeking cooperation from every source and at every avenue to put an end to any needless anesthetic mortality rate.

The surgeon often treats the anesthetic as a thing apart. Absorbed with the technical phases of the operation itself and with preoperative and postoperative treatment, in all of which he plays the dominant role, the surgeon sometimes comes to treat quite casually the anesthesia, which he does not himself administer. It is only after he has had the tragic experience of a sudden death of a private patient, coming even prior to or at the very outset of the operation, that the operator becomes keenly aware of anesthetic problems and takes an insistent interest in them. One quickly learns that the problems concerned in producing insensibility (or insensitivity as the case may be) are almost as technical and complex as those concerned in the operation itself. The large array of drugs, equipment, and optional methods in current use is baffling to any novice and to all but the true expert. Avertin, ethylene, amytal, the barbiturates, nupercaine, spinocaine, neocaine; rectal anesthesia, inhalation narcosis; the closed method,

* Prepared for the Executive Committee of the American Society of Regional Anesthesia. Read before the American Society of Regional Anesthesia, N. Y. Academy of Medicine, Dec. 8, 1931.

the open method; subarachnoid block, paravertebral block, field block, local infiltration,—how can these be mastered or even intelligently judged between without extended training and specialization? This question is answered beyond room for doubt in the percentage mortality of the various groups now allowed to administer anesthetics; mortality records which irrefutably demonstrate the meaning and value of specialization.

For the surgeon, then, the question has come to be not "what anesthetic" but "what anesthetist"? The surgeon's conscience cannot remain clear if his anesthetist be inexpert. But if the administrator be one of broad training and wide experience, an expert, the surgeon's anxiety is minimized. While the operator is not directly to blame for an anesthetic death and can, therefore, sidestep the immediate responsibility for such an occurrence, he is nevertheless responsible, in the management of private cases at least, for the choice of personnel. This report, and others like it, definitely show that by far the lowest mortality rate lies with the trained physician anesthetist.

That the interne has a right to instruction in anesthetic methods is an opinion strongly championed and stressed by our committee; but the right of the interne, when yet untrained, to assume full responsibility for the management and administration of the anesthetic, the figures of this investigation most emphatically deny! His natural restraints are inadequate. He is unaware of the degree of danger involved. There is no reason to expect that he should possess any practical knowledge as to apparatus, drugs, or death rate. And there is little more excuse for allowing the untrained interne to administer the anesthetic without direct and constant supervision than to allow him to perform the operation itself. No excuse as to convenience or economy can justify the continued use of the untrained interne anesthetist. This is perhaps the most valuable teaching of the present survey.

The relative success of the nurse anesthetist serves but to reemphasize the importance of the element of specialization and training. While the mortality rate of the interne anesthetist is 253 per cent greater than that of the trained physician anesthetist hers is but 35 per cent greater. This testifies to no greater native ability of nurse than of interne. We are all aware that anesthesias are given by only those particular nurses who have gone to considerable pains to qualify themselves for this work and who have had their credentials carefully examined. In sharp and unfortunate contrast, there are still many institutions in which any medical graduate, without proper regard to qualifications is allowed to take full charge of anesthetics, both general and regional. This is a particularly pernicious thing when closed methods of anesthesia are employed, involving the use of complicated apparatus, or when deep regional injections are attempted which depend for success and safety upon special preliminary grounding in details of neuroanatomy and physiology.

Dr. Bortone and his committee, then, in a study of the work done in 22 institutions and in a review of 50,000 anesthesias brand as avoidable fatalities and as the result of professional apathy and neglect, deaths which may be directly attributed to the unrestrained activities of inadequately trained anesthetists!

In the face of conclusions of such weight and significance emphasis upon lesser points in the survey may seem both irrelevant and detracting. Unfortunately, however, to make a critical review of this survey as is my assignment carries the necessity of bringing to note certain apparent flaws and points which might create erroneous impressions. This report has something of an official cast, representing as it does an investigation sponsored by the American Society of Regional Anesthesia and purporting to be a survey of anesthetic conditions in the State of New Jersey. We are under obligation to

guard against allowing unwarranted impressions to creep in unnoticed.

With these negative phases and criticisms I shall be brief. And I have, it is hoped, made sufficiently clear my respect for the major work and recommendations of this committee to necessitate no word of apology for other notations it seems important to add. My object is to indicate discrepancies rather than to give them stress.

First, a word is required as to the permissibility of expressing conclusions in terms of percentages; when we speak of the percentage mortality of the trained anesthetist group, the 35 per cent greater general mortality of the nurse anesthetist group and the 253 per cent greater mortality of the untrained interne anesthetist group, this use of percentage as the basis for comparisons is fair and legitimate since each group has dealt with many thousands of cases. But when we are speaking, not in terms of thousands or of hundreds, but of units, it becomes unfair to put conclusions on such a percentage basis; here we should express conclusions in specific numerals or units only.

To illustrate; this committee finds that 66⅔ per cent of institutions which furnish instruction in anesthesia and anesthetic methods are those classed as *Unapproved* by the American College of Surgeons; while only 47 per cent of those classified as *Approved Institutions* offer such instruction. The committee asks: "Is this not a small percentage of approved hospitals wherein instruction of this kind is offered?" The obvious answer, and one with which we heartily agree is "Yes, far too small." Yet this comparison of approved and unapproved institutions is an odious one in view of the fact that only three private institutions answered the questionnaires. This means that the impressive figure published in the report: "66⅔ per cent of unapproved institutions" (implying a study of conditions throughout the State of New Jersey) actually means but two private hospitals (the third offering inadequate data). And the results of work in these two institutions are compared on a percentage basis with results in twenty hospitals on the approved list. Such a comparison is obviously unjustified. It might be preferable to state: "About half, or specifically 9 of the 20 approved institutions included in this survey, offered instruction in anesthesia"; and to add; "of the three private institutions which answered the questionnaire, two offered such courses." The American College of Surgeons does too impressive, broad, and productive work for surgical betterment to justify this unwarranted implication of laxity in instruction regarding anesthesia within approved institutions.

It would be possible, placing upon a percentage basis all figures in the report, to draw certain almost ludicrous conclusions. Thus it might be made to appear that the interne anesthetist, against whom such serious criticisms have been leveled and who has an inexcusably higher death rate from the administration of inhalation narcotics than has the physician anesthetist or even the nurse anesthetist, may give all forms of regional and local anesthesias with relative impunity. For the figures show that this group (interne anesthetists) has given spinal anesthesias, paravertebral blocks, sacral blocks, and local blocks, without a single resulting death. The flaw in this line of reasoning is that although the interne group gave thousands of general anesthesias of the various types, yet they gave but 6 per cent of the regional anesthesias reported, from all institutions they gave but four sacral blocks, thirty-five conductive trunk blocks, etc. Here again is an instance, therefore, in which figures and comparisons when computed on a percentage basis would lead to erroneous impressions, due to the lack of adequate and justly comparable figures.

Again, on this same basis of criticism: the published results concerning the comparative safety of certain drugs and methods must also be taken *cum granum salis*. Among all groups (trained anesthetists,

nurse anesthetists, surgeon anesthetists and interne anesthetists) but thirty-two rectal anesthesias were reported. How can the percentage of safety of this method be fairly compared, let us say, with that of ether which was administered over 29,000 times? The merest trifle, either of luck or of misfortune, in the method used but thirty times, must affect the percentage result beyond all reason. Longer and larger studies are here needed for final conclusions on this point; and comparisons may be made only when numbers and conditions make such comparisons just.

The published suggestion that neocaine is the most unsafe local anesthetic agent falls within this same category of seemingly unwarranted assertions. This is particularly true since the dosages employed in some institutions surveyed ran as high as 240 mg. for spinal injections, even for very high injections. Our honorary president, Dr. Labat, advocates maximal spinal doses of but 120 mg. and does not himself at the present time approve, I believe, of high spinal injections, particularly those of large dosages of the anesthetic agents. Certainly he does not now advocate such levels for subarachnoid block as the upper dorsal and cervical regions except under the most unusual circumstances, if at all. May a drug be condemned or maligned upon the basis of records of its improper usage? No more than might ether or other agents be condemned upon the basis of results obtained from their administration in two to three times the safe dosage.

A word of caution might here be added concerning the dangers from a too ready acceptance for general trial and use of new drugs and anesthetic agents which continually spring up under the sponsorship of commercial houses. How often do such drugs make their appearance, how enthusiastically are their supposed advantages noised about, yet how frequently does a chain of fatalities follow their use, fatalities but slowly reported until finally a wave of certainly resultant deaths sweeps the dangerous product from the market? New drugs and advances are ever welcome; but should our personal employment of them not await a verification of their merits by a dependable research hospital rather than to rest solely upon the claims of those commercially interested or of enthusiasts directly connected with their acceptance and adoption?

My final criticism of the published conclusions in this survey has to do with the assertion that all regional and local methods combined are some 52 per cent more dangerous to life than are inhalation methods, considered collectively. This brings to notice the greatest shortcoming of this investigation; namely, the study of these deaths without reference to the types of operations performed and the preoperative conditions of these patients, i.e., without direct reference to risk. In many institutions spinal anesthesia is still reserved almost entirely for the bad-risk case. The recency of the revival to widespread use of spinal anesthesia ensures certain irregularities as to the manner of its routine employment. In these 22 institutions studied upon their 1930 records, 4880 spinal injections were made during the year; who, conversant with the trend, can believe that in these same institutions there were as many as 400 such injections five years earlier. Time, controlled figures and full definitions of terms (such as the drugs used, exact dosages, types of operations, and estimated preoperative risks, etc.) must be available before final conclusions may be reached. In inadequately trained hands spinal anesthesia is, we feel certain, a method fraught with danger; but we likewise believe upon the basis of many papers previously submitted to our Society that in adequate hands and under controlled circumstances the safety of spinal anesthesia is fully equal to that of many forms of inhalation narcosis. The report shows that in the hands of trained surgeons or regional anesthetists the spinal death rate was approximately 3 cases per thousand while that from avertin for example was 4 in a thousand. And I believe that

to publish as a true finding or fact under a survey of the American Society of Regional Anesthesia the statement that regional and local methods are 50 per cent more dangerous to life than are other methods results in a very erroneous impression. The statement is no more defensible on more careful study of the survey than are several which have already been brought to attention. Were the sweeping generalization actually true this Society would welcome it in order to sieze upon the opportunity clearly to define the circumstances making for greatest safety. But there can only be regret that this excellent report contains a statement so basically indefensible.

A point in the report which merits our special attention is that pertaining to the advisability of a more widespread use of purely local and field-block methods. For among all groups of anesthetist (internes, specialists, and surgeon anesthetists) not a single death resulted from such peripheral nerve blocking in over 7000 instances of its use. Our determination to attain greater perfection in such methods in which only a limited portion of the body is rendered analgesic, and our ambition to advocate more widespread use of local- and field-blocks, should immediately be made.

The problem of lowering anesthetic death rates is primarily one for the anesthetist to solve. But the solution cannot satisfactorily be reached without the cooperation of the surgeon. It should be determined that every aid be given in the creation, in all hospitals, of adequate departments of anesthesia; that vigorous efforts be made to see that these are headed wherever practical by trained physician anesthetists; and that rights and authorities compatible with their importance in surgical work, be granted to these specialists. The figures of this survey clearly demonstrate to the surgeon that his own best interests, as well as those of his patients, lie in this direction. Complete cooperation should be guaranteed to the surgeon's colleague, the trained physician anesthetist, who, by a wise selection of drugs and methods, works toward the common end of saving the lives of those who submit to operation.

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* Continued from p. 58.

ENDOCRINE FACTORS RELATED TO GENITAL DEVELOPMENT*

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UNTIL the first part of this century the medical conception of the endocrine glands, with the exception of the thyroid, was that of anatomical structures without function. Flajani, from clinical studies, had attributed function to the thyroid gland as early as 1802. The first two decades of this century offered proof that nearly all of the endocrine glands had a definite function, but with the exception of the cortex of the suprarenal gland, none was shown to be essential to life. Until this time these glands were thought to be functionally independent and entirely disrelated to one another or to the organs of the non-endocrine systems. Since 1922, during the last ten years, their functions have been intimately related to one another and definitely associated with the functions of the non-endocrine organs through the action of their hormones. Hence, it is now known that these glands form an interrelated system. Their inter-relationship from the interaction of their hormones serves as the best means of endocrinic interpretation. The hormonic action of distantly seated endocrine glands upon the genital system pertains particularly to the practice of urology and gynecology. This is true because the proper balance of the internal secretions from far-removed endocrine organs are the most important factors governing both the development and function of the gonads and their accessory organs. Heretofore specialists in these fields have considered their systems, exclusive of blood and nerve supply and general nutritional effects, as being independent of other bodily organs. For example, with the exception of the pathological processes of the urological organs such as infections, tumors, calculi, and their mechanical effects, extra-urological conditions beyond the pelvis or the kidney have received little attention as possible causes for their abnormalities. The endocrine relationships of the gonads have opened up a tremendous field, both with regard to the growth and function of the genitive organs and their accessories. In addition, this has demonstrated positive endogenous causation for many of their malformations and abnormal activities heretofore considered hopeless and incurable. A better understanding of this would present positive indication for the preventive treatment during the adolescent age of many of the abnormalities which the urologist and the gynecologist are called upon to correct during the postadolescent periods.

The general scheme of inter-relationship of these glands, as presented by the effect of the hormones of one upon the other, is divided into two hormonic phases. The *first* phase is that of the action of the homones of the thyroid, pituitary, suprarenal cortex, and the placenta (in the female) upon the follicle of the ovary, and the spermatic capsule of Sartoli of the testicle. The hormonic action of these endocrine glands induces cytological and functional changes in the follicle and the spermatic capsule which in turn result in a liberation of hormones from these structures of the ovary and the testicle. The *second* phase is that resulting from the hormones of the ovary and the testicle upon their accessory structures such as the uterus and its endometrium, tubes, and vagina in the female, and seminal vessels, prostate,

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† Dr. Engelbach died before reading the proofs of this article.

and external genitalia in the male.

FIRST HORMONIC PHASE

The *thyroid* during embryonic life exerts itself through its catalytic hormone, thyroxin, directly upon the gonads as a differential active principle. A deficiency of this hormone during fetal life frequently results in a lack of proper differentiation of the urological tissue as shown in cryptorchism at birth. This same effect upon the pituitary gland results in a lack of differentiation of this gland which supplies to the genital organs both its growth and sex hormones. The direct action of thyroxin upon gonadal function is that of inhibition. This is demonstrated clinically by the fact that the female cretin, in which thyroxin is deficient, has an earlier time of maturity by three or four years. Many cretins mature at the age of ten or eleven and some as early as eight or nine years. On the other hand, in the prepuberal hyperthyroidism when an excess of the inhibiting thyroxin is present during the adolescent age, maturity is frequently delayed for two or three years until the age of fifteen or sixteen. The age of the menopause in hypothyroid women is usually extended to forty-five years or more; whereas in hyperthyroidism the climacteric occurs at the age of forty or sometime before. On the other hand, thyroxin is necessary for fertilization as observed in cases of adult myxedema in which sterility is present.

The *hypophysis* is the most important endocrine gland in the body and is the center of hormonic action. Through its growth hormone, derived from its eosinophilic cells, it furnishes the body with its most important growth factor. A deficiency of this hormone results in a retardation of the statural characteristics and all the organs of the body including those of the genitive system. Hence, hypopituitarism involving the eosinophilic elements of the anterior pituitary accounts for genital hypoplasia in the male and the infantile uterus in the female. The pituitary sex hormones originating in the basophilic cells of the anterior lobe of the hypophysis acting upon the follicle of the ovary or the spermatogenic capsule

Fig. 1. Hypopituitarism, non-obese. Deficiency of both growth and sex hormones. (Left, 14 yr. 6 mo. Right, 17 yr.) Therapeutic reactions indicated by increase in height and development of primary and secondary sex characters.

of the testicle provoke maturity, and in the female stimulate the production of theolin of the ovarian follicle providing for the cycle of menstruation in the non-pregnant and progestin of the corpus luteum developing the placenta and maintaining the life of the fetus throughout gravidity. The posterior lobe of this gland supplies pituitrin, one of the functions of which is to produce uterine contraction for the expulsion of the fetus at term. The present conception of the pituitary sex hormone is described by Ascheim and Zondek as having two fractions, the ovulation and the luteinization hormones. Philip Smith of this city, who has done some of the most thorough and convincing work upon the hormones of the hypophysis, however, is inclined to believe that there is only one pituitary sex hormone, and that the cytological and hormonic effects upon the ovarian follicle are merely a continuation of the action of one active principle. The effect of the ovulation hormone is that

of the rupture of the ovarian follicle and the liberation of the ovum at maturity. The luteinization hormone causes the

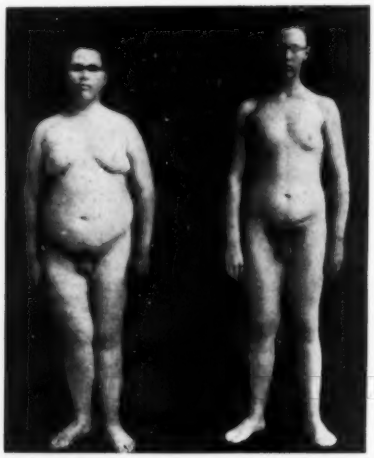

Fig. 2. Hypopituitarism, adiposogenital variety. (Left, 15 yr. 10 mo. Right, 17 yr. 8 mo.) Hypoplasia of genitals and absence of primary and secondary sex characteristics indicating deficiency of pituitary sex hormone. Therapeutic reactions indicated by development of primary and secondary sex characteristics.

hyperplasia of the lutein cells of the persistent graafian follicle during gravidity.

The *placenta* is believed by many to be an independent endocrine structure. Collip has extracted three incretory fractions from the placenta and the estrogenic preparation, amniotin, is obtained in large amounts from the amniotic fluid. Whether these principles having specific action are formed in the placenta or stored there is yet somewhat in doubt. Collip believes, however, that his preparation, emmenin, is an independent one on account of its different specific effects upon the follicle and the fact that it is potent when given orally. His other two fractions are similar to theolin and the pituitary sex hormone.

In addition to the hormones of the pituitary from the placenta which affect the ovary, there is probably a sex hormone derived from the *cortex* of the suprarenal gland. Although an active principle has been extracted from the suprarenal cortex by Swingle, Pfeiffer, Hartman, and others, the sex fraction so far has not been identified. Clinical observations, such as those observed in hypernephroma in childhood, would indicate that the associated hypergenitalisms of these tumors are probably due to a cortical hormone.

In addition to the direct action of the

Fig. 3. Hypopituitarism, adiposogenital variety. (Left, 14 yr. 5 mo. Right, 15 yr. 2 mo.) Hypoplasia of genitals and absence of primary and secondary sex characteristics indicating deficiency of pituitary sex hormone. Therapeutic reaction indicated by development of primary and secondary sex characteristics.

hormones of the hypophysis upon the genitive system, there is probably a reverse action of the hormones liberated in the ovarian follicle upon the pituitary gland. This is contended by Moore, Gallagher, and their coworkers of the Chicago University group. They maintain, for instance, that potent active principles from the ovaries and testicles produce an inhibition upon the hypophysis. This is important in so far that it would contradict the use of gonadal hormones as a means of stimulating either ovarian or testicular function. Consequently, the cause of maldevelopment or disturbed function of the gonads in either sex is essentially a prerequisite. The injection of ovarian or testicular preparations for gonadal anomalies due primarily to pituitary disorder would tend to increase instead of diminish them.

With the exception of the hormones derived from the placenta comparable effects from the hormones of these glands

upon the spermatic tissue of Sartoli of the testicle are present in the male to those affecting the follicle of the ovary in the female.

SECOND HORMONIC PHASE

The second hormonic phase is that resulting from the independent hormones derived from the follicle of the ovary and the spermatic tissue of the testicle upon the accessory organs of the gonads in each sex: the uterus, endometrium, tubes, and vagina in the female and the seminal vessels, prostate, and penis in the male. The development and function of these accessory organs are dependent almost entirely upon the hormones derived from their functionating gonadal tissue. As this paper was limited to the hypophyseal gonadal relationships, space will not permit of detailed description of this secondary hormonic phase of hormonic interaction. Suffice it to state, however, that it has been definitely proved that the endocrine glands forming hormones produce the first phase of an intermediate action through the gonads upon the accessory genital organs. This is proved by the fact that removal of the ovaries and testicles, which abolishes the action of the gonadal hormones, prevents both the growth and function of the accessory gonadal organs. The clinical application of such proof again emphasizes the importance of the differential diagnosis of endocrine disorders included in the first phase from primary gonadal endocrinopathies, and again explains the failure of therapeutic reaction when potent hormones are given for gonadal disorders which are due primarily to pituitary or other endocrine organs included in the first phase of interhormonic action. It also forcibly elucidates the point that in a hypopituitarism, to produce growth or function upon the accessory genitalia in the male, or the uterus in the female, there must be an unbroken chain of hormonic reaction from the hypophysis to the gonads and then from the gonads to the anomalous accessory genital organs. In addition to the proper solution of interhormonic action there is the proper balance of hormones and, particularly in the female menstrual cycle, the timing of their action. The latter are matters of diagnosis and are being solved by the careful clinical observations and investigations.

Fig. 4. Hypopituitarism, adiposogenital variety. (Left, 15 yr. Center, 16 yr. 8 mo. Right, 17 yr. 1 mo.) Statural growth within normal measurements indicating a sufficiency of growth hormone. Hypoplasia of external genitalia and absence of secondary sex characteristics indicating deficiency of pituitary sex hormone. Therapeutic reaction indicated by normal increment in growth, development of primary and secondary sex characters, and bodily hypertrichosis.

Four illustrative cases are appended. The first observation on two of these was made after the fourteenth year (Figs. 1, 3). The other two were first seen after the fifteenth year (Figs. 2, 4). Figure 1 shows all the classical signs of complete insufficiency of both growth and sex hormones of the hypophysis. The other 3 cases are adiposogenitalisms. At this age all had hypoplasia of external genitalia and absence of ejaculation. Antuitrin, an alkaline extract of the anterior lobe of the pituitary which has 20 to 50 per cent of the growth hormone as assayed by Evans, and a small fraction of the pituitary sex hormone as proved by Riddle, was given hypodermically, with the effect indicated in the legends.

METABOLISM OF SPERMATOZOA IN SEMEN

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THE urologists have put up to us, in the Department of Biochemistry, the problem of elaborating an artificial medium in which spermatozoa might be maintained motile for approximately twenty-four hours. The production of this medium necessitated a study of the factors influencing motility of spermatozoa in semen itself.

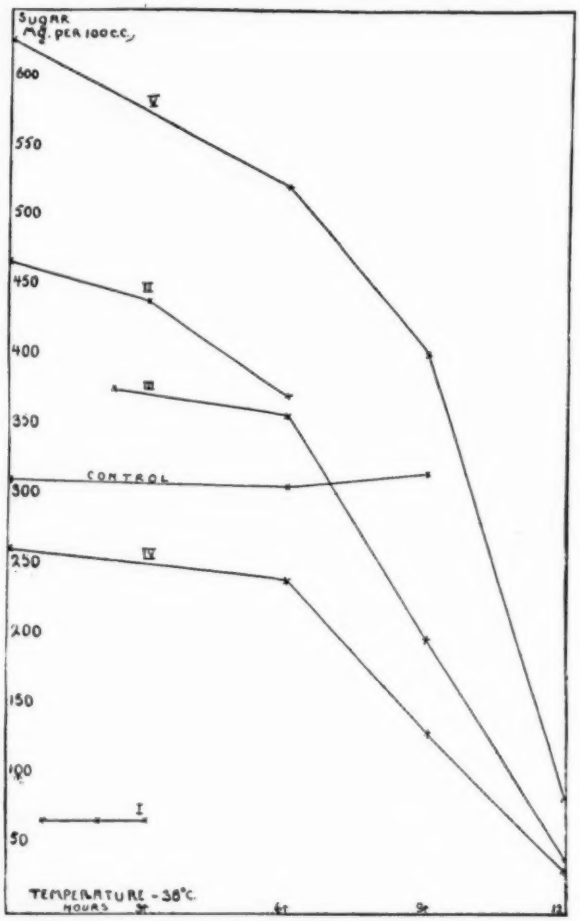

CHART I.

Chart I: Specimens of fresh semen under aseptic conditions were incubated at 38° and analyses for sugar were made immediately, and at three, six, nine and twelve hours of incubation. The sugar concentration of fresh semen is about four to six times that of normal blood. During incubation there is a continuous fall in sugar of the semen during the period of motility of the spermatozoa, that is, during six to nine hours. The control specimen, which was placed in a water bath at 90°C. for ten minutes before incubation, showed no loss of sugar during nine hours of incubation. One specimen, from a case of an old Neisserian infection, presented an unusually low sugar concentration (60 ml. per 100 c.c.), and no change in sugar during incubation. The specimen also contained no visible spermatozoa.

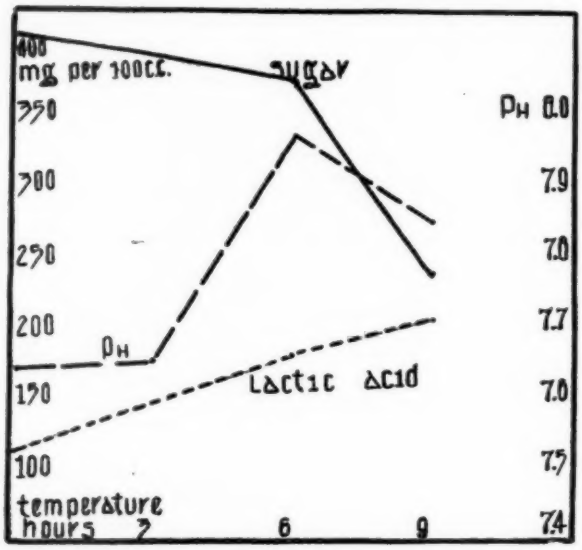

CHART II.

Chart II: Lactic acid is known to be an intermediate product in metabolism of carbohydrates. In the experiments exhibited in this chart we have followed changes in lactic acid simultaneously with changes in sugar concentration. Lactic acid concentration of the semen is approximately five times that considered normal for blood. As the sugar falls during

incubation, the lactic acid rises so that practically all of the sugar lost can be accounted for in lactic acid produced.

during glycolysis. A consideration of all of the phenomena exhibited by semen during incubation suggests that the loss of motility

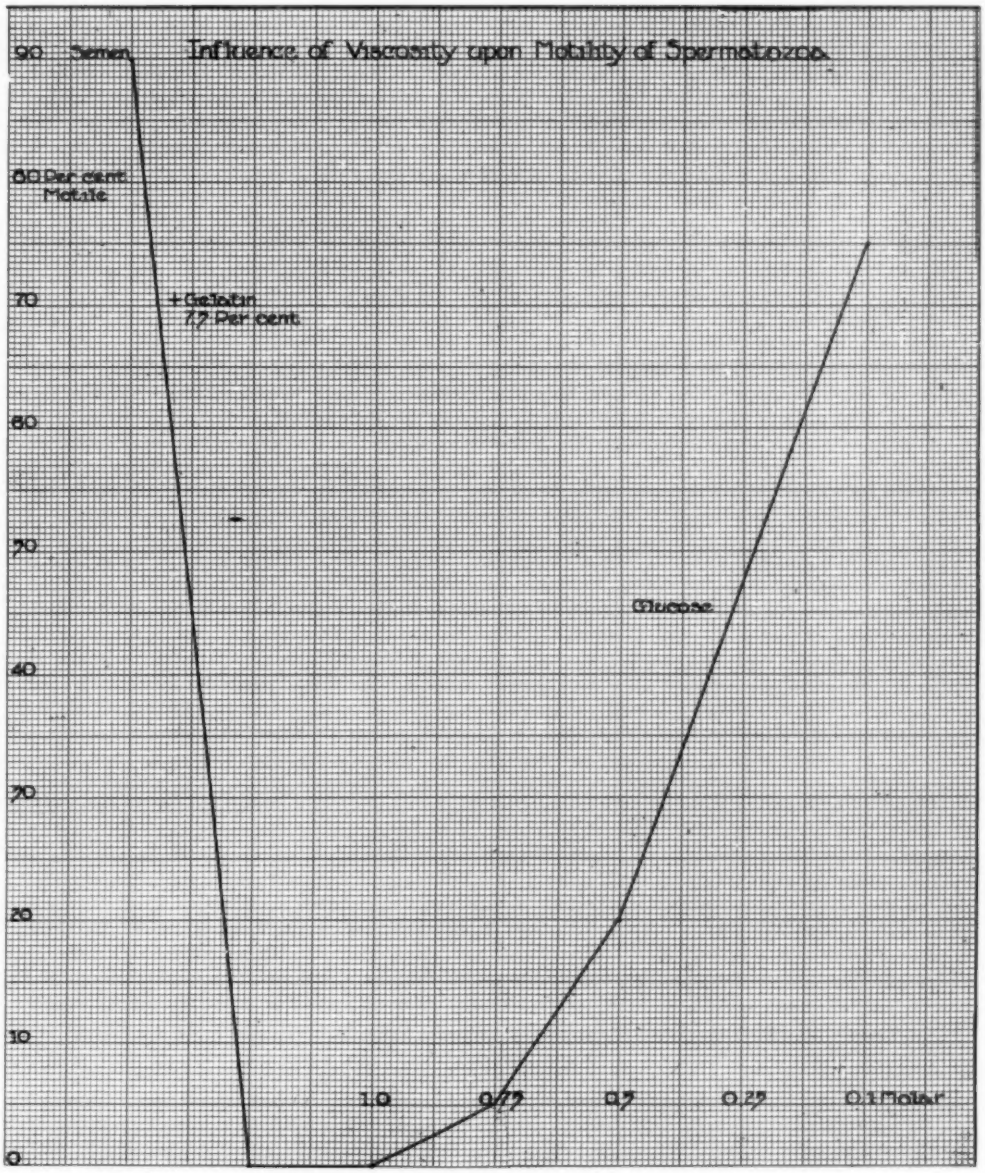

Chart III.

The reaction of fresh semen is slightly more alkaline than that of blood plasma. We have found the pH of specimens of semen to be approximately 7.6. During incubation of the semen the pH rises during the first three hours and subsequently falls. The rise in pH may be due to a loss of CO_2. The fall in pH, we believe, is due to the lactic acid accumulated

of spermatozoa may be due to one, or a combination of three factors.

1. A change in viscosity. It is a well-known fact that the gelatinous characteristics of the fresh semen rapidly disappear on standing.

2. A change in osmotic pressure of the semen.

3. A change in reaction of the semen.

In the following experiments we have attempted to study the influence of these factors upon motility of spermatozoa,

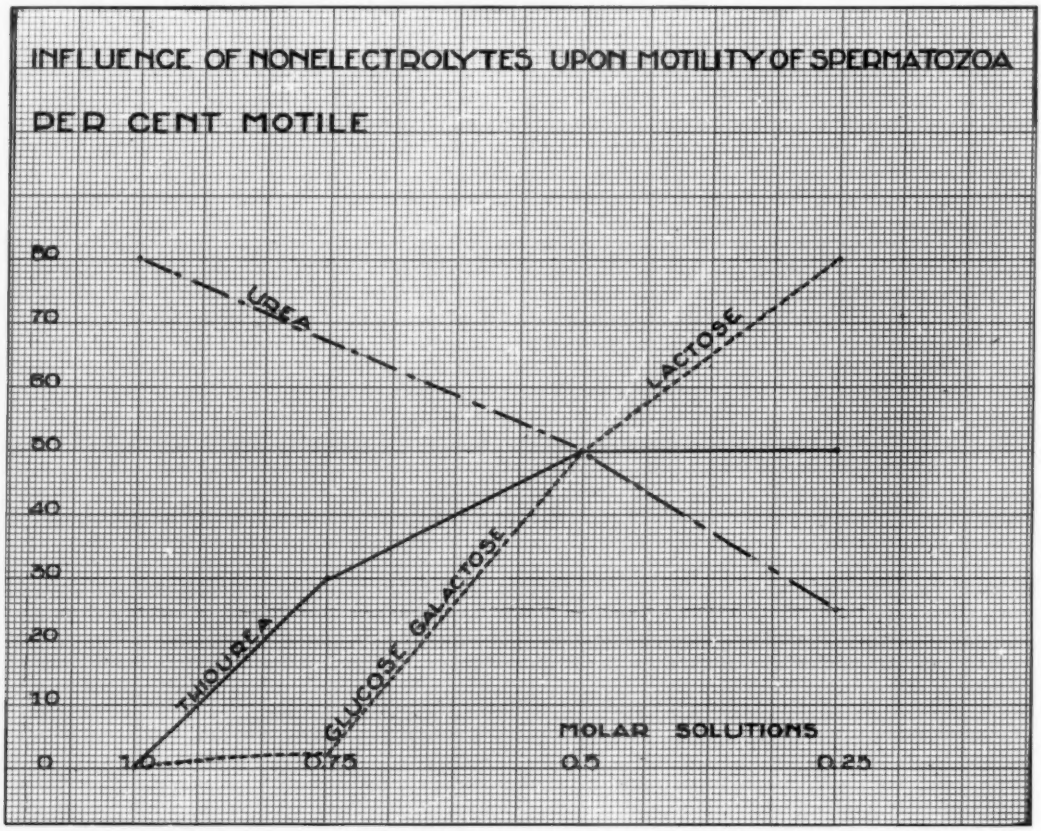

Chart IV.

considering only the relative number of motile spermatozoa to the total number visible in a microscopic field.

Chart III: This experiment illustrates the influence of viscosity on the motility of spermatozoa. To a specimen of fresh semen showing 90 per cent motility of spermatozoa, an equal volume of 3 per cent gelatine was added, buffered to a pH of 7.6. The time of flow in an Ostwald viscometer was increased nine times by the addition of the gelatine. No motile spermatozoa were visible. To samples of the semen plus gelatine, equal volumes of glucose of varying concentrations were added. As the molar concentration of the glucose solutions was diminished, the motility was inversely increased. The addition of 0.1 molar glucose solution restored 75 per cent of the original motility.

Apparently the motility of spermatozoa is dependent upon the viscosity of the medium. In general, the greater the viscosity, the less the motility.

Chart IV: In these experiments we have attempted to determine the influence of osmotic pressure on the motility of spermatozoa by adding solutions of different non-electrolytes to semen. Since osmotic pressure is a function of molar concentration of non-electrolytes, the greater the molar concentration, the greater the osmotic pressure. The sugars, glucose, galactose and lactose have similar effects upon the motility of spermatozoa. A 0.25 molar solution gives the maximum motility. The curve for thio-urea varies definitely from that for the sugars. Urea exhibits a third type of curve varying from all the others. The greater con-

centrations of urea give greater motility. The explanation for the effects of urea and thio-urea are not apparent but it is interesting to note that Kendall observed that urea has a negative effect upon viscosity of solutions. Semen contains an unusually high concentration of urea, about 60 mg. per 100 ml., more than twice that of blood.

Chart V: This chart presents graphs for the effect of electrolytes on motility. The electrolytes studied were of two classes, two-ion salts and three-ion salts. It will be seen that the addition of solutions of similar concentrations of the salts have a greater depressing effect on motility than that shown by the sugar solutions. The three-ion salts display a greater depressing action than that of the two-ion salts. Theoretically, if osmotic pressure of the semen is a factor influencing motility, this is the effect we should expect.

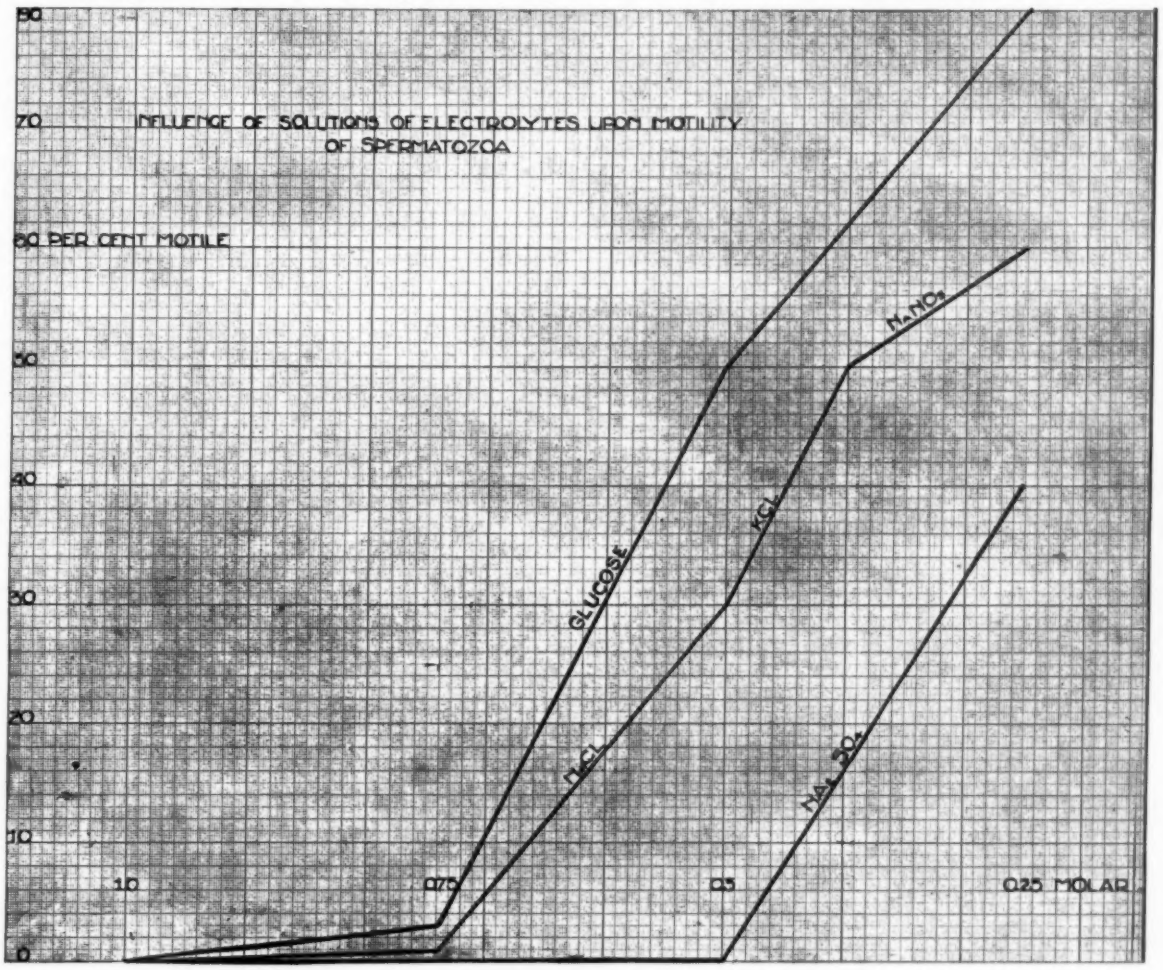

Chart V.

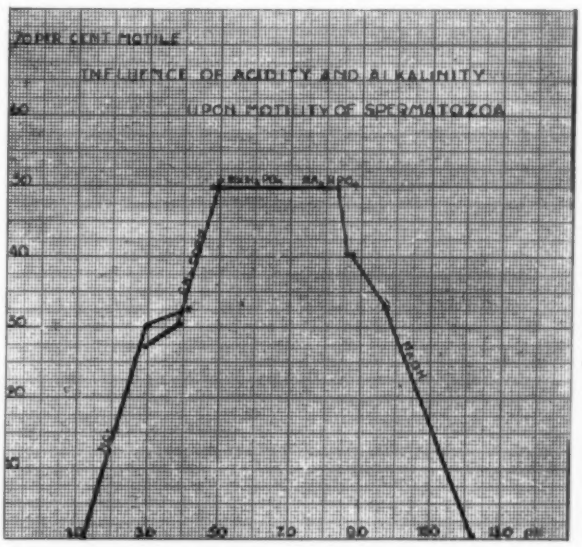

Plate VI.

[Concluded on p. 103.]

INTERNAL DRAINAGE

ITS SIGNIFICANCE IN THE PREVENTION & TREATMENT OF POSTOPERATIVE PULMONARY ATELECTASIS

MAURICE L. LUBIN, M.D.

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IN such a widely discussed subject as postoperative pulmonary atelectasis and regarding whose etiology opinions have been so diverse, there is little wonder that the prophylaxis and treatment of this condition have not been placed on a more rational basis. The problem of atelectasis is worthy of especial consideration because of its actual relationship to pneumonia. This fact was convincingly pointed out recently by Coryllos and Birnbaum.[1,2] The development of pneumonia on the basis of a preceding pulmonary atelectasis depends upon the duration of the atelectasis and upon the virulence of the organisms present in the secretions which occluded the bronchus and resulted in the collapse. The relationship between the two conditions has been impressed clearly upon me in several cases. At the autopsy of a sixty-five-year-old patient who died of bronchopneumonia ten days after its onset, the right middle and lower lobes showed scattered patches of atelectasis, which varied from 1½ to 4 cm. in diameter. The atelectatic patches were present amidst a field of marked pneumonitis. In addition to the generalized pneumonia, there was a beginning pneumonitis in the center of several of the atelectatic areas, and small casts of exudate were present in the terminal bronchioles leading to the surrounding airless parenchyma. Much pus and mucus were present in the trachea and right main bronchus.

The interrelationship between atelectasis and pneumonia was likewise demonstrated at the autopsy of a patient aged fifty-one, who died of a hemorrhage into the retrosternal space nine hours following a subtotal thyroidectomy. The entire right lower lobe was involved by an atelectasis and complicated by a fresh pneumonitis, and as in the previous case, much mucus and purulent material were found in the trachea and right main bronchus.

One cannot over-emphasize the fact that intrabronchial mucus and exudate readily lead to an atelectasis and pneumonia. Such secretions are commonly due to a coryza, tracheitis, bronchitis or chronic pulmonary suppurations.

Atelectasis and pneumonia are not uncommon occurrences among infants, debilitated and senile individuals, because such patients are unable to evacuate intrabronchial secretions and exudates adequately by cough and expectoration. Likewise, postoperative patients weakened either by the effects of a long operative procedure or by narcosis are prone to develop a pulmonary atelectasis and occasionally, a subsequent pneumonia.

The role which buccal and nasal secretions play in the development of this postoperative pulmonary atelectasis is of more importance than we have been led to believe. Observers[3–6] have shown that material introduced into the nose and buccal cavity of normal and unanesthetized individuals can be found in the trachea and major bronchi several hours later. The common head cold, with its complications of paranasal sinusitis and laryngitis, frequently furnishes the tracheobronchial tree with mucus and exudate. Wm. B. Faulkner Jr.'s studies on internal drainage[7,8] have disclosed the fact that bucconasal

secretions find their way into the trachea and bronchi of normal unanesthetized and wide-awake individuals in spite of an apparently perfect laryngeal protective mechanism and in spite of an intact cough reflex. Furthermore, he has convincingly demonstrated that when these secretions reach the tracheobronchial tree, they move about from place to place, plugging bronchi here and there, thus favoring the development of an atelectasis which is in no respects different from the type found following operation. Exudates present in the major bronchi, because of previous pulmonary pathology move about by internal drainage in a similar manner. The sites and type of such an atelectasis, as he has shown, and as I have been able to confirm, through physical examinations, lipiodol and *x*-ray studies and bronchoscopic inspection, depend upon the posture of the patient, the nature and quantity of the secretions and the size of the bronchial openings. Obviously, thin secretions, by entering minor bronchi, can produce a patchy atelectasis, while viscid material, on the other hand, is able to collapse an entire lobe or more, because large bronchial trunks are obstructed.

The movements of intrabronchial secretions can be controlled by the correct application of the principles of internal drainage. An appreciation of these factors will aid us not only in the prevention of postoperative pulmonary atelectasis, but will also help to decrease the incidence of postoperative pneumonia.

DIAGNOSIS

While the diagnosis of postoperative pulmonary atelectasis has been well standardized, the early recognition of this condition may be overlooked easily. The diagnosis of atelectasis in its incipiency is important in that it permits the earlier institution of treatment and the more prompt return of the atelectatic lung to normal. Consequently there is less likelihood of the development of a pneumonia.

The time of onset of postoperative atelectasis is variable. It may occur while the patient is still on the operating table, during the first few hours of the postoperative convalescence, or from one to five days after operation. The rapidity with which an atelectasis can occur has been demonstrated recently by Jacobaeus[9] when he observed its development during fluoroscopic examination as lipiodol was being introduced into the tracheobronchial tree. Similar experiences, not only with iodized oil, but also through detailed studies of patients with postoperative atelectasis, have led Faulkner likewise to the belief in such early occurrences. I have observed the sudden onset of right lower lobe atelectasis in a few cases as lipiodol was being injected into the right bronchial tree. In one patient the pulmonary condition cleared spontaneously after a coughing paroxysm, and in the other two, after they were promptly placed on their left side in a slight Trendelenburg position.

The suddenness with which a lobe may become atelectatic depends on whether the bronchial obstruction occurs at the end of an expiratory or an inspiratory phase. A bronchial occlusion in the former instance, when there is a minimal amount of air in the lungs, can produce an atelectasis in a very short time. On the other hand, when the bronchus has been plugged during the end of inspiration, an obstructive emphysema ensues, and the atelectasis will naturally be present only after the trapped air has been absorbed. This may require a time interval of from six to twenty-four hours from the onset of the occlusion to complete collapse.

An early manifestation of pulmonary atelectasis may be an elevation of the temperature which at first, fluctuating between 99° and 100°, may rise in some cases to 101°, 102° and even 103°, depending upon the amount of infection present. There may be a predominance or absence of respiratory symptoms. In the former instance the pulmonary condition is ushered in by dyspnea, cyanosis, rapid pulse and

chest pain. These are caused partially by the sudden mediastinal displacement resulting from the fall in intrapleural pressure on the involved side. The chest pain, though not frequently present in my experience, may likewise be accounted for by the tension of pleural adhesions, obviously the result of the increased negative intrapleural pressure. As the patient becomes more adapted to his intrathoracic disturbance, the respiratory embarrassment subsides. A gradually developing atelectasis disturbs the patient to a less degree because there is an absence of the sudden alteration in the intrapleural pressures and vital capacity. This degree of adaptation explains the severity of respiratory symptoms in some cases and the relatively mild clinical course in others.

Patients seen within twenty-four to forty-eight hours after the onset of the atelectasis often have a slight irritating cough with or without expectoration. The extreme viscidity of the sputum expectorated is noteworthy. Gray globular masses may be seen in some cases, while again in others the material is often purulent or mucopurulent. None of my patients expectorated bloody sputum.

PHYSICAL EXAMINATION

The early recognition of postoperative pulmonary atelectasis, contrary to general opinion, is at times dependent more on the physical examination than on the *x*-ray findings, for what may be elicited by the pleximeter finger and heard with the stethoscope often precedes the roentgenological changes. Minor degrees of atelectasis can often be diagnosed on physical examination and missed on the *x*-ray plate, particularly when the complication occurs on the left side and involves the area of the lung lying within the heart shadow, as seen on the roentgen film.

In pulmonary atelectasis, the degree of chest expansion is limited on the involved side, the intercostal spaces are narrowed and sunken, the trachea and heart are drawn towards the side of the lesion, and the diaphragm is usually elevated on the corresponding side. There is dulness with diminished or absent breath sounds over the involved lobe. In some cases the auscultatory findings have shown the presence of bronchial breathing and crepitant râles over such an area. When only an upper lobe is involved, the trachea may be the only structure displaced.

In the presence of an obstructive emphysema, however, the physical signs over the involved area are a dull tympany with absent or diminished voice and breath sounds. Occasionally, one may discover a contralateral displacement of the heart, especially evident at the end of expiration. A dilated pupil and a flushed cheek may at times be seen on the side of the lesion in both atelectasis and emphysema.

Of striking interest is the fact that very frequently, the signs elicited over the chest of a patient with atelectasis are found to alter from two to five minutes after the first examination. These transient physical findings occur after the patient's posture has been changed and deep breathing exercise encouraged. Interestingly too, when such signs disappear over an atelectatic lobe and no appreciable expectoration has taken place, the signs of the presence of secretion or of an intrabronchial plug may appear over another portion of the same or opposite lung. This new area usually lies in a position dependent to that portion of the lung which was previously involved and is a development caused by the shifting of the intrabronchial secretions from one bronchus to another as the patient changes his posture. For example, the signs over a right upper lobe atelectasis may disappear after the patient has been placed in the semi-Fowler position and encouraged to take deep breathing exercises, and new signs appear over the right lower lobe. Similarly, the movements of secretions from a left lower lobe to a right lower lobe

bronchus by manipulating the posture of the patient, will often be followed by a disappearance of characteristic physical signs over the left lower lobe and an appearance of like signs over the right lower lobe. Such alterations in the physical signs going hand in hand with postural changes speaks well, therefore, for the migration of secretions within the tracheobronchial tree by the mechanism of internal drainage. (Figs. 1, 2.)

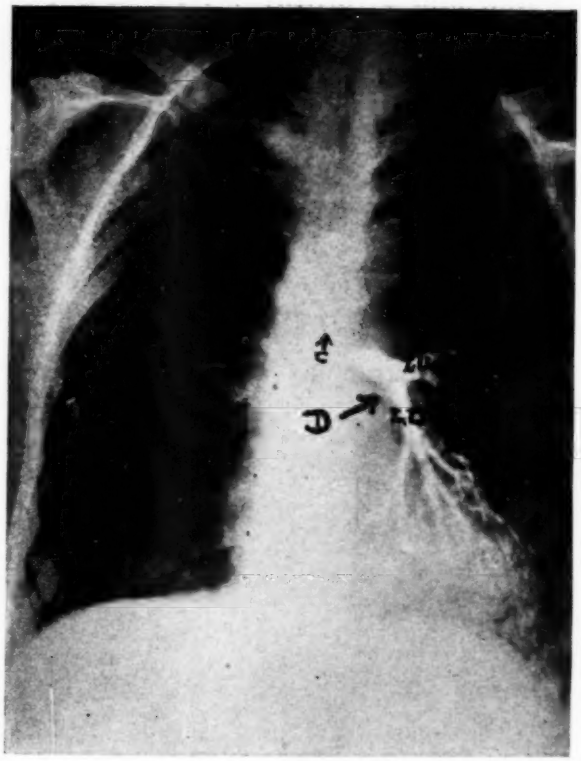

Fig. 1. Campiodol visualization of left bronchial tree when patient is in erect position. Observe absence of iodized oil on right side. C, Carina. D, Division of left main bronchus into left upper (L U) and left lower (L L) lobe bronchi.

The usual order of frequency in which the various lobes are involved by postoperative atelectasis are: right lower, left lower, middle, left upper and right upper.

X-RAY FINDINGS

The roentgenological findings in the early cases of atelectasis may reveal only a slight homogeneous grayness of the involved lobe without any definite signs of heart and mediastinal displacement. The mediastinal structures would likewise remain in their normal position if a bilateral atelectasis of same degree were present. In the advanced cases, the homogeneous shadow is denser, the mediastinal structures are drawn over towards the side of the involvement, the diaphragm is elevated on the corresponding side and there is both an increase in the downward slant of the ribs as well as a narrowing of the intercostal spaces on the affected side. Any one of these signs may stand out predominantly over the others.

Fig. 2. Same case as Figure 1, showing that movements of oil can be controlled by manipulating posture of patient. *X*-ray plate was taken after patient was changed from an erect posture to one lying on right side. Note that iodized oil is disappearing from left lung and is spilling by internal drainage into right bronchial tree.

When an obstructive emphysema is present, the position of the diaphragm is often lower than normal and the heart is displaced to the opposite side. The latter finding is often well manifested when the roentgen film is taken at the end of expiration.

Scattered bronchial obstructions, so frequently produced by thin secretions, result in a patchy atelectasis which often simulates a bronchopneumonia on the *x*-ray film. Obviously, there will be an absence of heart and mediastinal displacement

if the sum of atelectatic areas is of insufficient magnitude to produce an appreciable drop in the intrapleural pressure.

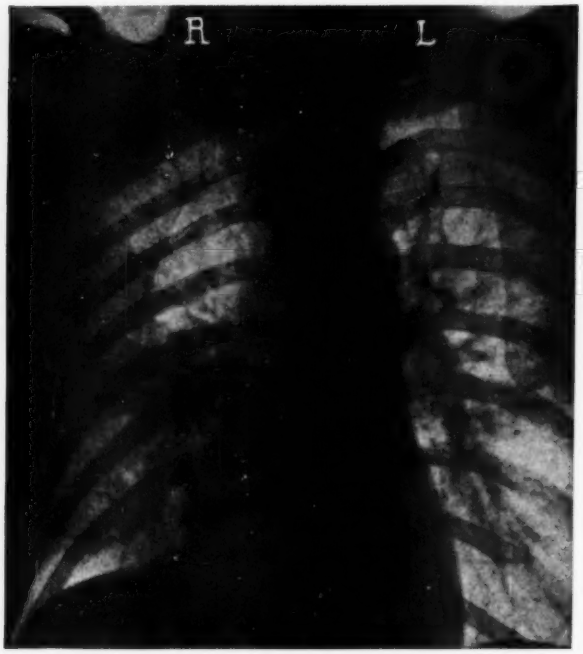

Fig. 3. *X*-ray of chest taken immediately after pulmonary complication was discovered. Note that heart is displaced toward right, diaphragm is high on that side and intercostal spaces are narrowed.

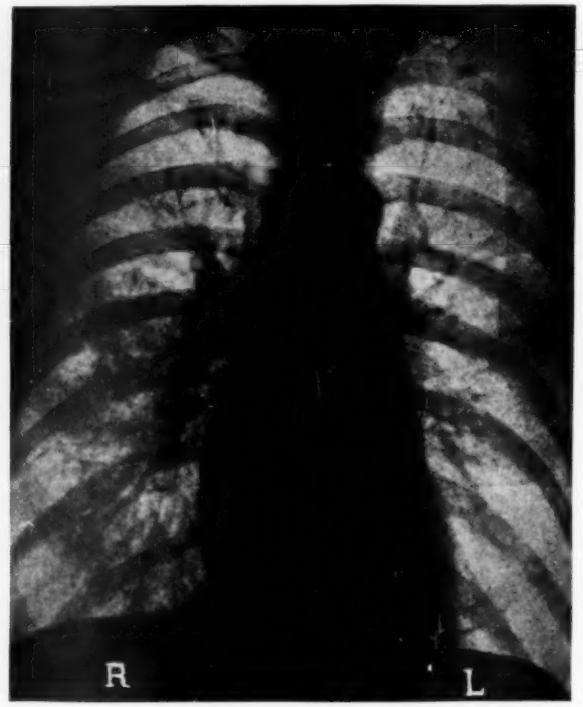

Fig. 4. Same case as Figure 3. *X*-ray plate taken fourteen hours after treatment was instituted. Heart and right diaphragm have returned to normal positions, and right intercostal spaces are wider.

PROPHYLAXIS

As in all other diseases in Medicine, prevention should be our aim. We can accomplish this, first, by adopting measures to prevent the drainage of secretions into and throughout the tracheobronchial tree, and secondly, by obviating conditions favoring the collection of secretions within the bronchi. To minimize the quantity of secretions and the amount of infection in the trachea and bronchi, patients with a postnasal drip and those with or recovering from a head cold or bronchitis should be carefully observed and treated by the rhinologist before operation. The only exception to this preoperative care is met with in emergency surgery.

Attention should be directed to the patient's mouth hygiene. The painting of the gums with Berwick's dye[10,11] has been found to be most efficient for this purpose because it attenuates the organisms and decreases the bacterial count of the buccal secretions which are likely to be aspirated.

Patients who are suffering from chronic pulmonary suppurations as tuberculosis, abscess and bronchiectasis often have excessive amounts of pus and mucus in their bronchi. These exudates and secretions must be evacuated by adequate postural exercises preoperatively. If postural drainage is not successful, a bronchoscopic aspiration just before operation can often prevent a postoperative atelectasis and pneumonia. The semi-Fowler position as used by many Continental thoracic surgeons during operation is often hazardous regardless of the minimal amount of inhalation anesthesia used, because this posture facilitates the drainage of secretions into and throughout the tracheobronchial tree and interferes with proper expectoration. Many of the contralateral and homolateral atelectases and pneumonias developing after major thoracic surgical procedures performed for the relief

of chronic pulmonary suppurations are due to the spilling of contents which have been pressed out of the diseased areas during operation. Such exudates flow to dependent portions of the bronchial tree, either in the same or opposite lung, obstruct bronchi, set up infection and produce pulmonary complications. The dangers of the semi-Fowler position during operations upon the lungs and pleura can be minimized by the prompt bronchoscopic removal of excessive intrabronchial material before, during, or at the conclusion of the operation as the indication arises. Then, too, the timely use of the bronchoscope will occasionally prevent an acute suffocative death on the operating table, the result of the flooding of the trachea or major bronchi by exudates. Faulkner[12] has shown, in a recent analysis on the causes of sudden operative death, that such accidents are due to the unfavorable mechanism of internal drainage.

The use of suction for removing secretions that have accumulated in the mouth, nasopharynx and trachea during operation is a procedure that cannot be overemphasized, for it diminishes the amount of material that would otherwise be aspirated into the bronchial tree.

Of the inhalation anesthetics used today the combination of nitrous oxide and oxygen is probably the least dangerous.

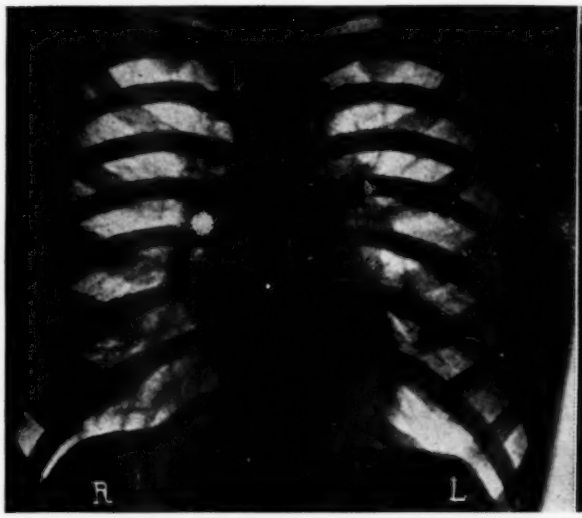

Fig. 5. Preoperative roentgenogram showing normal chest. (Courtesy, Dr. Wm. B. Faulkner, Jr.)

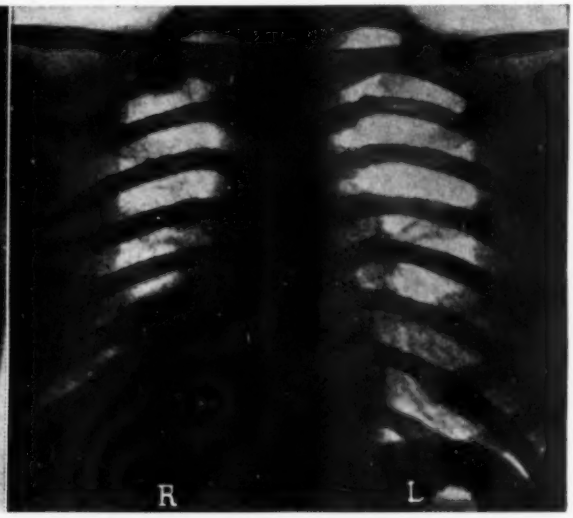

Fig. 6. *X*-ray plate of chest six days after pelvic operation. Physical examination of chest had shown an atelectasis of right lower lobe. There was diminished expansion of right thoracic cage, heart and trachea were pulled to right and there was marked dulness with diminished breath and voice sounds over right lower lobe. (Courtesy, Dr. Wm. B. Faulkner, Jr.)

If ether is to be employed, a light narcosis should be used where possible, for the act of coughing can often dislodge a bronchial plug and restore the ventilation to an atelectatic lobe. Patients who have received a deep ether narcosis should be de-etherized at the conclusion of the operation. A chest examination is of value at this time for by determining the presence of a bronchial occlusion, the patient can be placed in an appropriate posture during the process of de-etherization.

The use of tight dressings and binders should be minimized where possible. Abdominal distention should be prevented.

Postural exercises along with carbon dioxide inhalations are beneficial even during the first three days following operation and should be administered four times daily.

TREATMENT

In order to restore an atelectatic lobe to normal and prevent any immediate

recurrence, treatment is directed along the following lines: (a) postural drainage; (b) hyperventilation; (c) the administration of expectorants; (d) inhalations; (e) bronchoscopy. To understand clearly this treatment let us briefly review what is taking place in the respiratory tract of postoperative patients who develop a pulmonary atelectasis. When such patients are returned from the operating room to the ward they are usually placed on their back, either in the supine or semi-Fowler position, and unfortunately often remain so for hours and days without a postural change. The failure to change the patient's posture permits bucconasal and tracheobronchial secretions to pool in the most dependent areas of the bronchial tree. These pooled secretions find dislodgment difficult because of the unfavorable posture and debility of the patient, the depression in the pulmonary ventilation and the viscidity of the secretions.

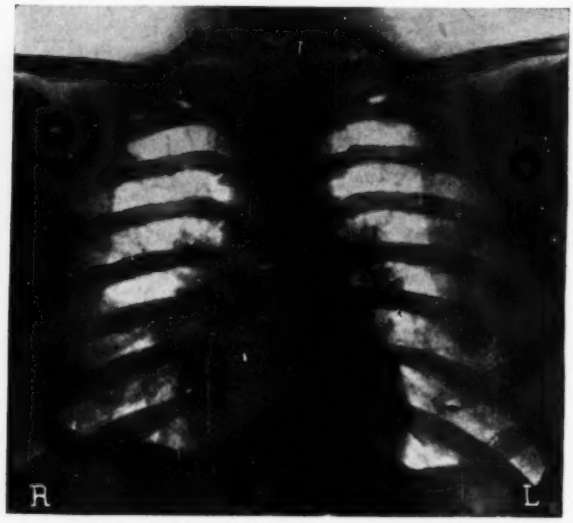

Fig. 7. *X*-ray taken on seventh postoperative day ten hours after bronchoscopy. Note that chest has returned to normal. (Courtesy, Dr. Wm. B. Faulkner, Jr.)

Postural exercises are of extreme value in the treatment of these cases. The appropriate postures selected which are conducive to favorable results are dependent on a knowledge of the anatomy of the lungs and an understanding of the relationship of one bronchial opening to another. In order to appreciate fully what is happening to secretions in the bronchial tree under the effects of postural changes one should know the axial relationship between the major bronchial stems and the longitudinal and horizontal planes of the body.

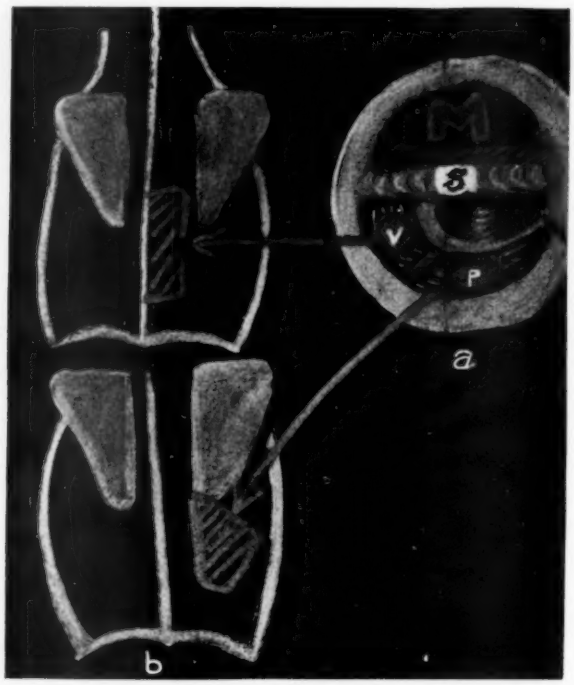

Fig. 8. A. Bronchoscopic sketch representing view at level where right main bronchus divides into middle and lower lobe bronchi. M, Middle lobe bronchus. S, Septum. Entire lumen below (S) represents lower lobe bronchus. P, Posterior minor bronchus and V, vertebral minor bronchus arise from posterior and medial walls of lower lobe bronchus respectively. B. Representation of posterior chest wall where physical signs are elicited when posterior or vertebral minor bronchus is occluded. A plug at (P) can give signs of an atelectasis below angle of scapula, but when (V) is occluded, lower mediastinal portion of right lower lobe becomes atelectatic. (After Wm. B. Faulkner, Jr.)

The turning of postoperative patients from side to side as a means of preventing postoperative pulmonary atelectasis was first employed by Sante[13,14] in 1927. He also successfully treated a few patients who had developed this pulmonary complication. The details of administering postural exercises were further developed by Wm. B. Faulkner, Jr. at the University of California and the San Francisco County Hospitals

and are based on the principles of internal drainage.

In the treatment of a right lower lobe atelectasis, the atelectatic area is placed uppermost so as to facilitate the drainage of secretions from the involved bronchus. The patient is rolled on his left side almost to a prone position and the foot of the bed is raised. He is allowed to remain in this posture for fifteen or twenty minutes, and is then rolled on his right side for a few minutes. The latter maneuver, by preventing a stasis of secretions which might have flowed into the left bronchial tree, insures the movement of the intrabronchial material towards the larynx, where it can be evacuated by cough and expectoration.

In dealing with a middle lobe atelectasis the patient must lie on his back for fifteen or twenty minutes, with the foot of the bed raised, because the anatomy of the middle lobe and its bronchus is such as to require that position for best drainage.

A left lower lobe atelectasis should be treated by raising the foot of the bed and placing the patient on his right side in a semi-prone position. After the necessary time interval has elapsed, a matter which depends on the physical findings elicited over the involved lobe, he is rolled on his back and then on his left side for a minute or so to prevent the stasis of secretions in the right bronchial tree.

It must be emphasized that a patient should never be allowed to remain in a given position too long. I have in mind one with a left lower lobe atelectasis who was permitted to lie on his right side in a Trendelenburg position for two hours. The secretions from the left lower lobe spilled across the carina and plugged the right upper lobe bronchus, producing an obstructive emphysema of the corresponding lobe. To obviate such occurrences, the semi-Fowler position should be included in the maneuvers for a few minutes five times a day, because the upright position almost invariably helps to drain the upper lobe bronchi. Obviously, a right upper lobe atelectasis is treated by placing the patient in the semi-Fowler position and inclining the body a little to the left.

The respiratory depression so frequently present in postoperative patients interferes with the effectiveness of postural exercises and should be dealt with early in the treatment of postoperative atelectasis. Inhalations of pure undiluted carbon dioxide gas are very effective in overcoming this depression in pulmonary ventilation. Extremely weak patients and those who are cyanotic because of diminished blood oxygen tension should be given inhalations of 5 per cent carbon dioxide in oxygen to relieve the anoxemia and afford comfort.

The causes of the respiratory depression can be attributed to preoperative and postoperative administration of narcotics, anesthetic, reflex splinting of the diaphragm and the thoracic cage, extreme abdominal distention, subdiaphragmatic gas, tight dressings and binders. Consequently, these patients have difficulty in taking deep breaths voluntarily. Such shallow respirations can be easily overcome, however, by a few whiffs of carbon dioxide given from time to time. The gas is administered every half hour or hour depending upon the individual requirements, care being exercised not to fatigue the patient. The inhalations are given for twenty seconds, a rest period of from one to two minutes follows, and again an inhalation is administered. If the gas is given properly, the patient will experience four or five series of deep and rapid respirations, within from five to seven minutes.

During a period of hyperpnea the patient is placed in the appropriate posture and the chest is examined to determine whether air is passing beyond the intrabronchial plug. Indeed, much information concerning the behavior of intrabronchial secretions in atelectasis has been obtained in this manner. If the patient is in the proper posture, is not extremely debilitated, and the bronchial occlusion is not complicated by edema and granulation tissue about the bronchial lumen, the stimulation of the respiratory center with the subsequent increase in the depth of respiration permits

air to pass beyond the plug of bronchial secretion. The resultant expiratory blast is then sufficient to dislodge and expel it.

These inhalations are administered at indicated intervals, depending on the judgment of the medical attendant, until the pulmonary condition has cleared.

Since tenaceous secretions are a handicap to the foregoing treatment, large doses of potassium iodide solution are given to facilitate expectoration. Sodium bicarbonate inhalations in the form of sprays or steam are extremely beneficial in liquefying tenaceous exudates, scabs and crusts that may be present in the tracheobronchial tree.

When a thorough trial at postural exercises, carbon dioxide inhalations and expectorants has failed to show any improvement after twelve to thirty-six hours, bronchoscopy has been resorted to with startling results. There have been only a few patients who required bronchoscopic treatment. The failure to improve under the general measures already discussed, as manifested by the persistence of symptoms, physical signs, and *x*-ray findings, are due to one or more of the following: marked debility or non-cooperation of the patient, an intrabronchial plug of viscid or thin secretions complicated by inflammatory edema and granulation tissue about the bronchial lumen, and an inspissated mucus plug or crust within the bronchus.

Tenaceous intrabronchial plugs may be dislodged bronchoscopically and removed with suction. If dislodgment is difficult, the application of cocaine and adrenalin to the involved bronchus will facilitate matters greatly. On the other hand, when plugs of secretion are hemmed in by edema and granulation tissue, the shrinking of the edematous mucus membrane with cocaine and adrenalin and the cauterization of the granulations with silver nitrate solution restores the bronchial lumen to more nearly normal patency and permits an easier evacuation of the secretions through the bronchoscope. The bronchoscopy can be performed very rapidly under local anesthesia and in expert hands should be anything but trying for the patient. Carbon dioxide inhalations and postural exercises are always continued when the patient is returned to the ward.

Our results with the treatment of atelectasis have brought up a few interesting matters which warrant discussion. In the first place, if frequent appropriate postural changes are neglected, this combined carbon dioxide and postural therapy may at times fail to improve the patient's condition and it may even aggravate it, for if the mobilized secretions are not expectorated, they will naturally gravitate to dependent areas, and set up an atelectasis at new sites. For example, a patient with a right upper lobe atelectasis was allowed to remain in the semi-Fowler position for several hours. When seen twenty-four hours later, the right lower lobe was completely atelectatic while the right upper was normal.

Similarly, when patients with a lower lobe atelectasis are given carbon dioxide inhalations in the upright position without subsequent appropriate postural changes, the secretions already present in the lower bronchial stems will gravitate more deeply into the lower lobes. It is particularly true when the secretions are thin. The terminal bronchioles and alveoli are not immune to the entrance of thin fluids from the major bronchi. This has been brought to my attention recently in two patients who came to autopsy following suffocation. In the first case, blood that had been aspirated following a severe epistaxis, appeared in many of the alveoli and bronchioles of both lower lobes. The second case showed a similar picture following the aspiration of blood after rupture of an esophageal varix.

Patients recovering from a postoperative atelectasis have been classified according to their response to treatment. One type of patient showed a rapid termination of his pulmonary condition soon after therapy was started:

This patient, a male aged forty-nine, progressed normally for four days following a right hernioplasty under spinal anesthesia. On the fifth postoperative day he developed a temperature of one hundred and three, a respiratory rate of 28, and complained of sharp right-sided chest pain. He began to cough and expectorate small amounts of tenaceous purulent sputum. A physical examination of the chest having revealed an atelectasis of the right lower lobe, an *x*-ray was immediately taken (Fig. 3) and the patient placed on the carbon dioxide and postural treatment. During the first ten minutes of the treatment the patient was seized with a coughing paroxysm and he expectorated a few chunks of green tenaceous material. An examination of the chest at this time showed an improvement in the voice and breath sounds and a decrease in dulness over the involved lobe. This improvement was followed fourteen hours later by a complete amelioration of symptoms. The temperature dropped by crisis, the pulse and respirations returned to normal and the *x*-ray revealed a normal chest. (Fig. 4.)

One meets with another type of atelectasis where the pulmonary condition clears suddenly by crisis after three or four days of treatment. These patients do not fall into the group requiring bronchoscopy because daily observations have given evidence on physical examination of air entering the atelectatic lobe from time to time, a sign of transient plugging and unplugging of the involved bronchus. The return of the lung to normal is the result of the final expulsion of the obstructing intrabronchial material.

The following types of patients, requiring bronchoscopic treatment, have been segregated into two groups. In one, the atelectasis clears immediately following bronchoscopy. In the other, the lung returns to normal following two or more bronchoscopies, at twenty-four to thirty-six hour intervals.

The rapid return of an atelectatic lobe to normal following a bronchoscopy was experienced in a patient treated forty-eight hours after the onset of the pulmonary complication. The mucus plug was found to be so tenaceous and tightly wedged into the right lower lobe bronchus as to render removal difficult. Its removal was followed in a few minutes by a disappearance of the atelectasis, for both physical signs and *x*-ray pictures obtained immediately after the bronchoscopic procedure revealed a normal chest.

Another patient developed a temperature of 103°F. and an elevated pulse rate on the sixth postoperative day following a pelvic procedure under spinal anesthesia (Figs. 5, 6 and 7). She was markedly toxic, cyanotic and dyspneic. The cough was persistent and the sputum was tenaceous and purulent. No type of case better illustrates the difficulty of differentiating atelectasis from pneumonia than the one under consideration. The medical staff favored the diagnosis of pneumonia, while those of the thoracic surgical group felt that the pulmonary condition was probably an atelectasis. A bronchoscopy was performed immediately (Wm. B. Faulkner, Jr.). Purulent material was removed from the right lower lobe bronchus, and the abnormal physical findings and symptoms disappeared promptly following this procedure. The results of the bronchoscopy conclusively proved the pulmonary condition to be an atelectasis. This change in the clinical course of the patient following such treatment is in keeping with what occurs in other cases of atelectasis.

A third patient developed an atelectasis of that part of the right lower lobe supplied by the vertebral and posterior minor bronchi. The pulmonary condition cleared after the first bronchoscopy (Fig. 8).

Patients in whom the atelectasis fails to clear shortly after bronchoscopic treatment, may be often expected to present a bronchial mucosa red and swollen and the bronchial lumen occluded by edema and occasionally by granulation tissue. Such a condition was demonstrated in a patient who came to bronchoscopy seventy-two hours after the onset of the pulmonary collapse. Three bronchoscopies with intrabronchial medication over a four day period were required before the edema about the middle and right lower lobe bronchial openings had sufficiently de-

creased to permit the normal egress and ingress of air to these lobes.

A patient may occasionally be selected for bronchoscopy where no intrabronchial plugs are seen on examination. The failure to find such plugs may be explained as follows: In one instance, the intrabronchial material is probably coughed up and expectorated either during the preparation for bronchoscopy, or while the patient is being transferred to the operating room. On the other hand, the secretions responsible for the atelectasis may be so thin that they gravitate into the minor bronchi and disappear from view. If the latter condition be true, a chest examination in the operating room will still show the presence of the atelectasis after the bronchoscopy. The instrument should be passed to the bronchus suspected of being plugged and the lumen treated with cocaine and adrenalin, even though no plug be seen. The rationale of this procedure is based on our past experience in interpreting and correlating physical signs of the chest with what is found on bronchoscopy, when dealing with pulmonary suppurations. This has made it possible often to predict, on physical examination alone, the site of an occlusion of even a bronchus of the second order. Thus, if signs of an obstructive atelectasis are elicited over a definite area below the angle of the scapula, the posterior minor bronchus will usually be found occluded (Fig. 8).

We must not forget that many patients who develop a postoperative atelectasis recover spontaneously from two days to three weeks following the onset of the condition. On close analysis, these patients are found to have unintentionally treated themselves by turning in bed, and by coughing and expectorating the intrabronchial secretions. Our judgment should not be influenced, however, by such spontaneous recoveries, for a few patients, when untreated, will experience less fortunate results.

The unfavorable outcome in an improperly treated case of atelectasis was illustrated in an uncooperative forty-five year old laborer, who had sustained a fracture of the left humerus. Following the application of the Thomas splint, he remained on his left side the greater portion of the time. The patient's mouth hygiene was extremely poor so that the buccal secretions which drained into the left bronchial tree not only led to an obstructive atelectasis, but surely afforded ample opportunity for infection. Consequently, a left lower lobe atelectasis was well established five days after the application of the splint and the continuance of the faulty posture. A slight nonproductive cough had developed and the temperature rose to 99.5°F.

The chest examination disclosed an impaired percussion note with diminished breath and voice sounds over the posterior portion of the left lower lobe. Cooperation was wanting, the patient persisted in lying on his left side in a semi-Fowler position, and the result was that the pulmonary condition became progressively worse. On the seventh day following the onset of the atelectasis, cough and expectoration increased, the sputum became viscid and purulent but not foul, the temperature rose to 102°F. and the pulse and respiration rates were elevated. There was a difference of opinion as to the diagnosis at this time. Since no effort was made to evacuate the intrabronchial exudate and treat the inflammatory bronchial mucosa, which was undoubtedly present, pneumonia, pulmonary abscess, empyema and pulmonary gangrene followed. I am convinced that had energetic treatment and bronchoscopy been resorted to during the early stages of the atelectasis the fatal outcome would have been prevented.

Postoperative pulmonary atelectasis can be prevented, it is amenable to treatment, and if more of us will give this pulmonary complication the consideration that it warrants, the patient will not only be spared an unnecessary burden during his postoperative convalescence, but the incidence of postoperative atelectasis and postoperative pneumonia will be diminished.

CONCLUSIONS

1. The prophylaxis and treatment of postoperative pulmonary atelectasis demands a clear understanding of the mech-

anism of its etiological factors, namely internal drainage.

2. By internal drainage is meant the movement of secretions from place to place within the tracheobronchial tree so that bronchi are occluded and infection is spread. The movements of these secretions are dependent upon the posture of the patient, the nature and quantity of the tracheobronchial secretions and the size and course of the bronchial stems.

3. Buccal and nasal secretions, by gravitating into the tracheobronchial tree even during the presence of the cough reflex, play a significant role in the production of pulmonary atelectasis and pneumonia.

4. The early recognition of postoperative pulmonary atelectasis is important for two reasons: First, it allows an earlier institution of treatment, and facilitates a more prompt return of the atelectatic lobe to normal; secondly, it obviates the dreaded postoperative pneumonia which may occur in atelectasis of longer duration.

5. The administration of postural exercises, carbon dioxide inhalations and expectorants are of proven value in the treatment of postoperative pulmonary atelectasis.

6. Bronchoscopy, in specific instances, warrants a place in our armamentarium for the prophylaxis and treatment.

7. An appreciation of internal drainage and the proper application of its fundamental factors can diminish the incidence of postoperative pulmonary atelectasis and postoperative pneumonia.

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COMPLETE & PERMANENT REMOVAL OF TOE NAIL IN ONYCHOGRYPOSIS & SUBUNGUAL OSTEOMA

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THERE are a few conditions where the toe nail has to be sacrificed even by the most conservative surgeon. A plastic operation for complete and permanent removal of the toe nail with a comparatively short period of convalescence is here offered for trial.

The big toe nail is usually the one that presents this problem. The operation consists of a U-shaped incision surrounding the toe nail, the free ends of the U extending proximally to the head of the basal phalanx. Another slightly concave, opened distally, incision is made through the skin, covering the root of the nail. This incision crosses the long axis of the toe, and connects the two sides of the U. The dorsal structures, consisting of the edge of the skin around the nail, the matrix of the nail, and the nail itself, are entirely removed, particular care being taken to leave any parts of the nail. About one half the distal portion of the terminal phalanx is exposed subperiosteally and resected. This leaves a short dorsal and long plantar flap. The plantar, tongue-shaped flap is now turned over the stump of the terminal phalanx and sutured to the shorter dorsal flap, as is clear from Figure 1 A, B, C).

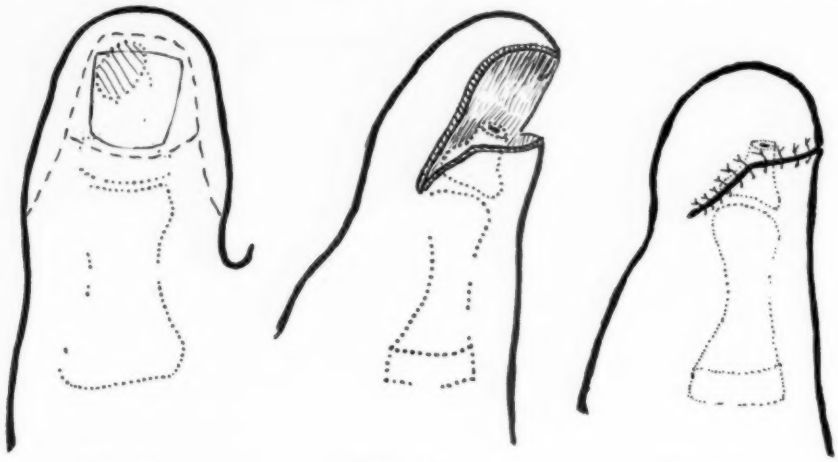

FIG. 1A. FIG. 1B. FIG. 1C.

FIG. 1. A. Interrupted line shows U-shaped skin incision. Note that base of dorsal flap is wider than its distal part because ends of U are extended in a slightly dorsiplantar direction. Dotted line represents outline of bones with subungual osteoma (lined obliquely). B. Toe nail with its matrix completely removed and distal part of terminal phalanx resected, leaving a short dorsal and a long plantar flap. C. Plantar and dorsal flaps approximated and sutured together.

In about two to three weeks (in cases of primary union of the wound) the patient may resume his work, wearing the usual shoes. This operation is indicated in cases of onychogryposis, subungual osteoma, and in other diseases and deformities of the nail where the patient and the surgeon feel that complete removal of the nail is the most desirable procedure. This same procedure may also be offered in certain cases of badly deformed ingrown toe nail, without infection, where more conservative treatment has failed, or seems unlikely to give relief.

The surgeon is warned against indiscriminate sacrificing of the toe nail, reserving this operation only in cases where the use of this somewhat mutilating (at least from a cosmetic point of view)

procedure is a choice of the lesser of two evils. This should especially be taken into consideration with women, where preservation of a toe nail may sometimes mean a great deal of mental comfort to the patient.

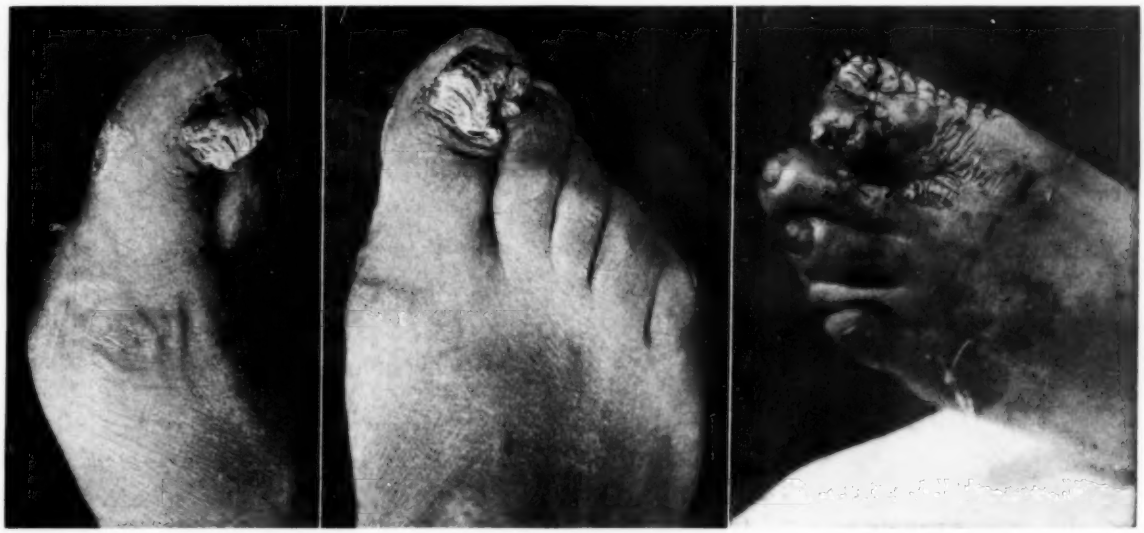

Fig. 2A. Fig. 2B.

Fig. 2. A. Case of marked onychogryposis which developed a few months following injury in a man fifty-five years old. A heavy object fell on top of his big toe, causing also oblique fracture of head and shaft of the basal phalanx. B. Same case, three days after operation. Incision in this case was extended unnecessarily far proximally.

The writer believes that in cases of marked onychogryposis (Fig. 2 A) this operation is definitely indicated, if the patient agrees to have it performed. The deformed toe nail often tears stockings, sometimes interferes with wearing shoes, and causes pain and pressure upon the adjacent toe. The complete removal of the toe nail in these cases also improves the appearance of the foot.

There may be some controversy regarding the use of this operation in cases of subungual osteoma which may be removed without sacrificing the nail. However, it has been the writer's experience that in the majority of these cases, the osteoma is located very superficially beneath the matrix, usually under the distal part of the nail. The toe nail very often is already deformed at the time when the patient seeks medical advice (Fig. 5). The operation for subungual osteoma should almost always consist of resection of the distal part of the phalanx, to prevent a possible recurrence of this condition. Whether this is done by first avulsing the nail and approaching the osteoma through the matrix, or whether the distal part of the phalanx is exposed through a U-shaped incision, there always is a considerable trauma to the matrix of the nail. In any event the new nail grows again, usually becoming deformed and causing discomfort to the patient. The period of postoperative recovery and the disability is considerably prolonged after these conservative operations, requiring sometimes six to eight weeks before the patient is able to wear shoes. Eventually in most of these cases where more conservative operation is used, aiming to remove the osteoma and preserve the toe nail, the patient seeks medical aid, perhaps from another surgeon, presenting an unsightly and often disabling and painful deformity of the toe nail (see Fig. 3).

The writer is under the impression that the afore-described complete removal of the toe nail and partial resection of the phalanx should also be the operation of choice in the majority of cases of subungual osteoma, especially in working people,

where quick restoration of earning ability is more important than the esthetic problem.

FIG. 3.

FIG. 4.

FIG. 3. Appearance of toe of girl fifteen years old, eighteen days after afore-described operation. She was operated on twice previously for subungual osteoma without resection of terminal phalanx. Third operation was performed because of tenderness of distal part of terminal phalanx and deformity of toe nail. Patient was completely well at time this picture was taken.

FIG. 4. Case of subungual osteoma in a woman twenty-four years old, a few months after operation. Very good functional and fair cosmetic result. Toe nail was already deformed before operation.

A few details of the technique are worth being stressed:

1. The importance of a thorough removal of the nail with the matrix, as has already been mentioned.

2. Enough of the distal part of the terminal phalanx should be resected to prevent recurrence of the osteoma, and also to secure loose approximation of both flaps without any tension, which may interfere with the circulation mainly of the dorsal flap and even cause its necrosis.

3. As Figures 1 A, B, and C illustrate, the sides of the U-shaped incision should be made in a somewhat dorsiplantar direction making the base of the dorsal flap wider than its distal part. This will prevent cutting of the branches of the dorsal digital arteries and assure adequate blood supply to the dorsal flap.

4. When removing the root of the nail, care should be taken not to open the interphalangeal joint; which, however, is a minor complication.

FIG. 5. Preoperative roentgenograms of subungual osteoma in a girl fourteen years old. Note deformity of toe nail (arrow). Resection of distal part of nail phalanx was performed in this case without complete removal of toe nail. Result was a badly deformed nail growing upward, perpendicular to long axis of toe.

The operation is very easily performed under local block anesthesia, and requires only a few minutes. It leaves a painless toe. The cosmetic result can also be considered fairly good, especially when compared with the pre-existing condition (Figs. 2 A, B, 3 and 4).

SUMMARY

A plastic operation for complete and permanent removal of the toe nail is described.

This operation is offered for cases of onychogryposis, subungual osteoma, and any deformity of the toe nail where complete removal of the nail is indicated.

THE BRADFORD FRAME

AN EFFICIENT MEANS OF SECURING REST*

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ANN ARBOR, MICH.

OVER sixty years ago H. O. Thomas[1] considered prolonged and uninterrupted rest, properly enforced, excellent treatment for a great variety of medical and surgical conditions. The importance of his idea has been slowly recognized by the medical profession. It is my purpose to re-emphasize its importance, briefly to call attention to its value in therapeutics, and to show that some of our modern advances in the treatment of disease depend upon its application. Lastly, it is hoped that a brief discussion of this simple yet insufficiently used physiological therapeutic aid will stimulate others to its more frequent use.

There is no more fascinating chapter in the history of medicine than that which witnesses the realization that pulmonary tuberculosis must be treated by prolonged, enforced and uninterrupted rest. This doctrine, gradually entrenching itself in the minds of the followers of Trudeau, has led to the development of the rest-producing surgical procedures, pneumothorax, phrenic interruption, thoracoplasty and pneumolysis.

Recently we have been impressed by the rapid collapsing and filling in of tuberculous pulmonary cavities in patients who had associated hip or spinal tuberculosis, as compared to patients with pulmonary lesions only. We believe that this is not because there is an essential difference in the type of infection, but simply because they have been kept at more perfect rest. At the University Hospital patients with spinal or hip joint tuberculosis are completely immobilized on Bradford frames, those with hip involvement first being placed in a long hip spica. It is our opinion that for proper healing of a tuberculous joint permanent local rest must be surgically induced at the proper time by a fusion operation. Furthermore, we firmly believe that such a joint heals

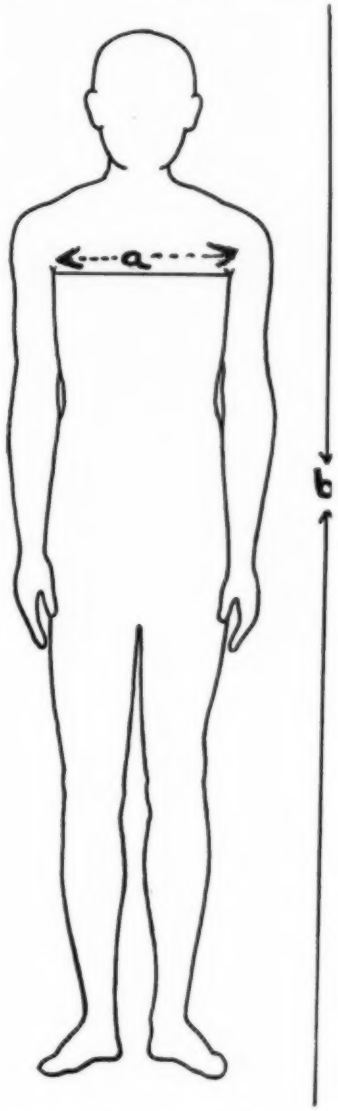


FIG. 1. A. Measurements necessary for Bradford frame. (a) Width: axilla to axilla. (b) Length: length of patient plus 2 inches.

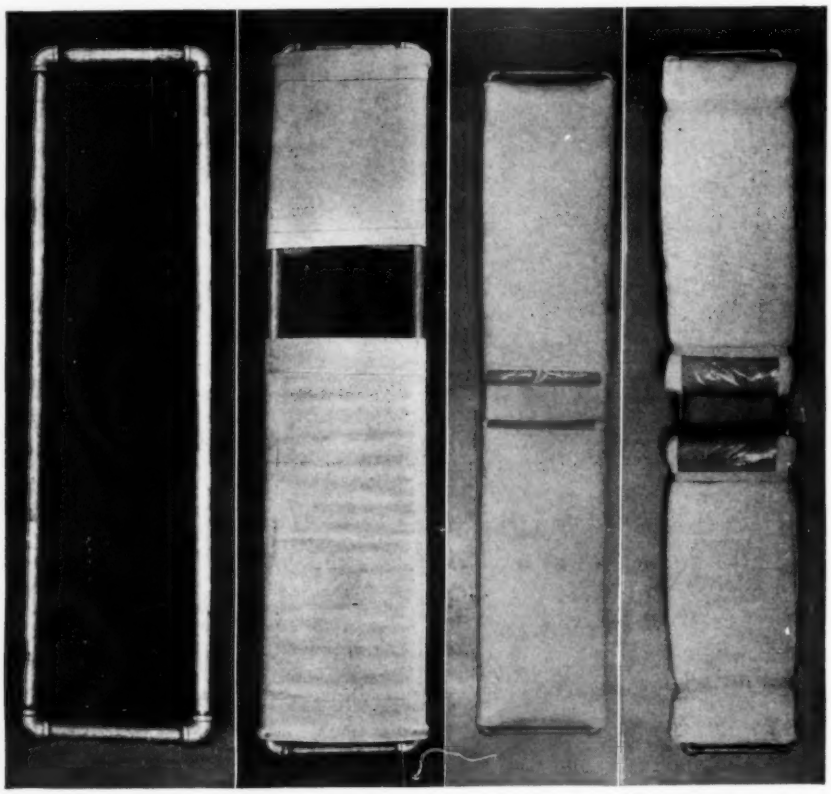
[1] Keith, Sir A. Menders of the Maimed. Oxford Univ. Press, 1919, p. 35.

* From the Department of Surgery, University of Michigan.

more quickly, more efficiently and more permanently if the entire patient is placed at rest during the process of repair.

USES

On the surgical service at the University Hospital, Ann Arbor, the use of Bradford



B C D E

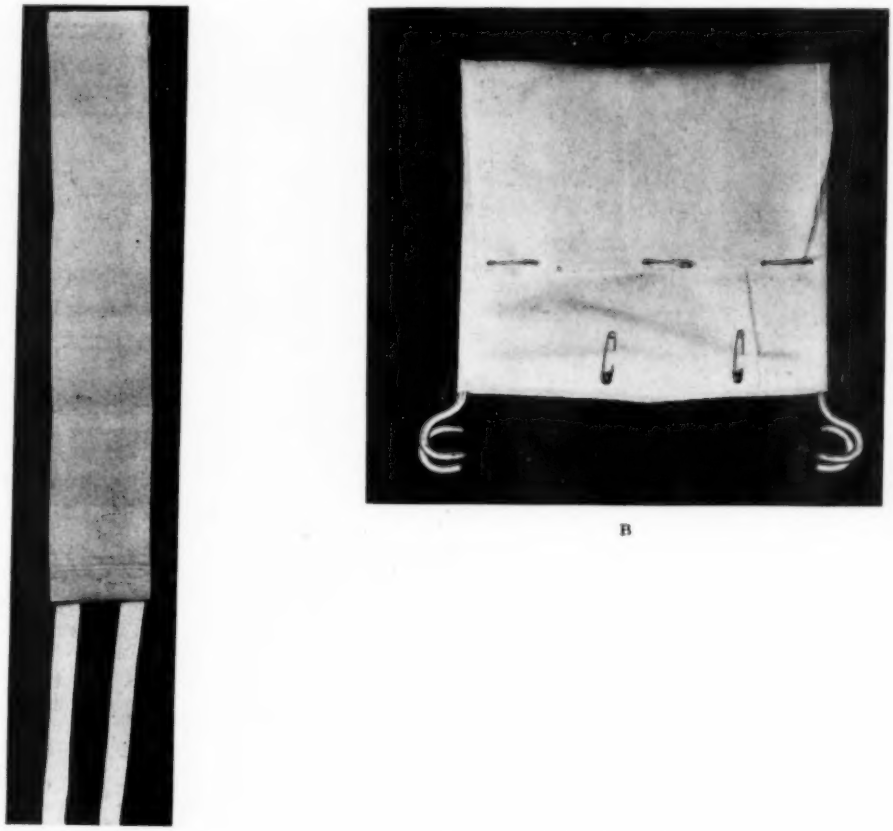
FIG. 1. B. Posterior frame uncovered. C. Posterior frame plus firm canvas covering at each end. D. Posterior frame plus canvas plus cotton pads. E. Posterior frame fully covered with buttocks support, without foot piece.

Due to the teaching of Orr,[1] the past few years have witnessed a radical change in our treatment of chronic osteomyelitis, although there has been no essential change in our operative technique. Formerly osteomyelitic extremities were half-heartedly immobilized in insufficiently long plaster casts or moveable splints and daily dressings were done. We now know that the more perfectly these extremities are immobilized, and the fewer the dressings, the better are the end results. When feasible, if the entire patient is placed at frame rest the healing process will be favored.

[1] Orr, H. W. The treatment of chronic osteomyelitis. *Surg., Gynec., Obst.*, 45: 446, 1927.

frames has increased tremendously during the past few years. In addition to their use in osteomyelitis and tuberculosis as already mentioned, fractures and deformities which require traction, burns which necessitate skin grafting and post-operative herniae in children are treated on frames. The spine is protected from the danger of scoliosis in postoperative perinephritic abscess, lung abscess and empyema. Bradford frames overcome difficulties encountered in keeping at rest patients who are suffering from certain pathological conditions of the extremities as rickets and freshly healed fractures in which weight bearing is painless and apt to result in considerable bowing. Their use in the treatment of infantile

paralysis and fractures of the spine is well known. They also prevent the development of deformity and facilitate nursing two or three times daily. Such limited active motion is sufficient to maintain muscle tonus.



A B

FIG. 2. A. Canvas buttocks support for bare area of posterior frame. B. Upright foot piece for posterior frame, inferior view, to show construction.

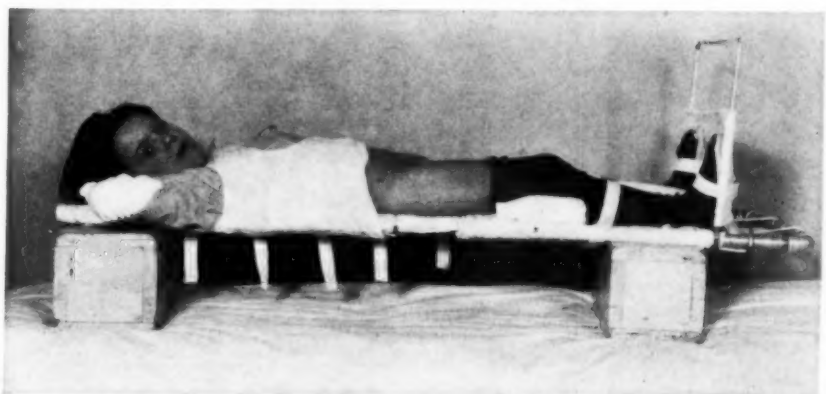


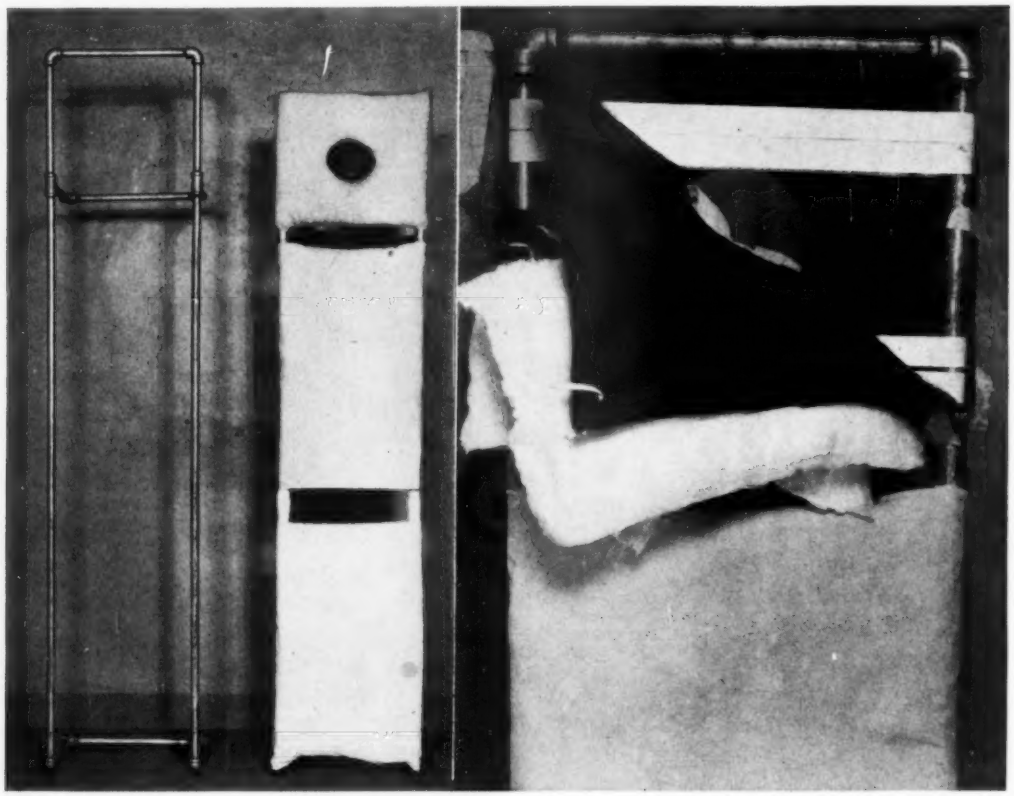
FIG. 2. C. Child at rest on posterior frame, arm pillows removed. Note buttock, foot, and knee supports. In this case foot piece is wrapped in plaster of Paris. Buckle straps around dorsum of feet fit through holes in plaster. Blocks raise frame from bed.

care. Normal shoulder, hip, knee and ankle joints do not become stiff if the patient puts them through a full range of motion

CONSTRUCTION OF FRAMES

The Bradford frame is rectangular and constructed of ⅞ inch gas pipe. It is 2

inches longer than the patient and its width is determined by the width of the patient, measured from axilla to axilla space approximately 4 inches wide about three-fourths the length of the frame from the head. This free space is kept covered



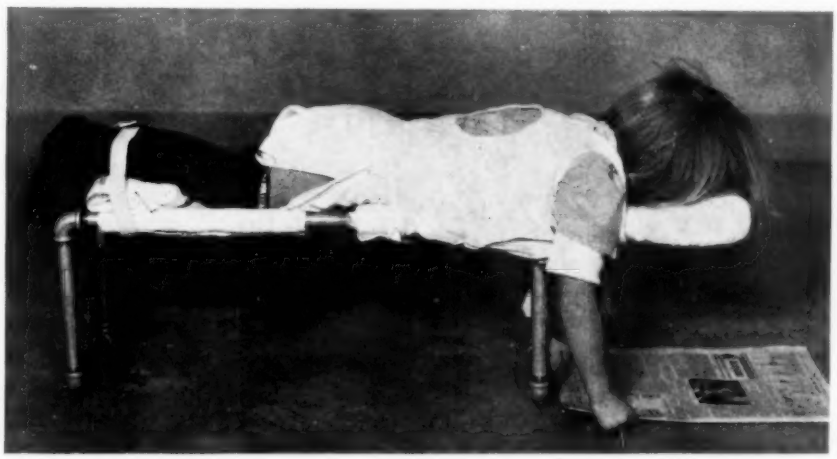
A B

FIG. 3. A. Anterior frame uncovered and completely covered. B. Showing construction of face rest, black felt base.

FIG. 3C. Restraint jacket.

(Fig. 1 A). Each end of the frame is covered with firm canvas equipped with buckles (Fig. 1, B and C). This leaves an uncovered by a narrow, buckled, canvas support (Fig. 2 A) which can be removed for the use of the bed pan. At the foot, a cloth covered steel upright is sprung on the frame (Fig. 2 B) to hold the feet in dorsiflexion. Long, cotton-filled pads are placed next to the canvas (Fig. 1 D) and over these, soft cotton sheeting is tightly stretched and pinned (Fig. 1 E). The arms rest on two or three pillows placed on each side of the head. If the patient is young and is to be on the frame only two or three weeks, the posterior frame only is necessary. However, if the patient is to remain at frame rest for some time an anterior frame is provided (Fig. 3 A). It is constructed like the posterior frame except that 14 inch gas pipe props are attached at each end to raise the patient from the bed. This length is necessary to permit the

patient to read properly (focal distance of eye). It is covered only as far down as the ankles so that the patient's feet hang over the end in dorsiflexion. The face rests on an oval window in a thick felt support which takes the weight of the head on the forehead, malar eminences and chin (Fig. 3 B). It is not infrequently necessary, particularly in young children, to use some means of restraint. For this purpose a canvas jacket is used (Fig. 3 C). Covering the frame requires a considerable length of time but is not difficult and is one of the routine duties of our undergraduate nurses. At the University Hospital we do not attempt to keep a stock of Bradford frames, feeling that frames made to fit everyone never properly fit anyone. When a frame is returned to the Appliance Shop it is immediately dismantled and the parts saved. In a short time such a collection of parts permits the assemblage of almost any sized frame on a moment's notice. The frames illustrated can be easily and cheaply constructed by a plumber and can be readily convexed or concaved to suit the individual patient.



A

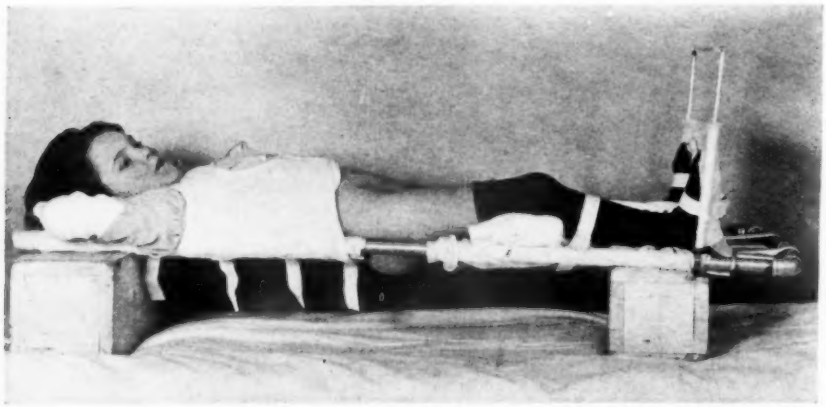
B

Fig. 4. A. Child at rest on anterior frame B. Child at rest on posterior frame, lower extremities in abduction

Children accomodate themselves to frame routine without the slightest inconvenience, while adults may have considerable difficulty during the first week. Abdominal distention associated with constipation and pain are not infrequent if the patient is forced to remain on the frame for too long a period at a time. He should gradually accommodate himself to the

frame, and during the first day should spend only a few hours on it. The time should be slowly increased until at the end of a week he remains on the frame twenty-four hours of the day. The patient is turned once daily, spending twelve hours on his anterior and twelve hours on his posterior frame. This is accomplished by placing him between the two frames, strapping them both to his trunk and thighs and then turning him over (Fig. 5 B).

We believe that the Bradford frame affords a more perfect form of physical rest than any other now at our disposal. If the frames fit properly the patient is always comfortable. No excess movement is allowed, and all energy is made available for the healing processes.



A

B

FIG. 5. A. Improper position on frame. Note prolapse of buttocks. B. Patient being turned.

OLD TRAUMATIC DISLOCATION OF THE PATELLA

OPERATIVE CORRECTION*

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NEW YORK CITY

THIS case is being reported because it is a condition which is very rare, and because the result obtained is unusually good. Dislocation of the patella following paralysis is seen rather frequently, but a dislocation of the patella without a fracture due to trauma, of the bones making up the knee joint is of infrequent occurrence.

On September 16, 1929, Mrs. E. D. was struck by an automobile and thrown to the road. She was found unconscious, and removed to a hospital where she was under treatment for eight days. During her stay at the hospital, an *x*-ray examination was made, and no fracture being noted, it was determined that several ligaments were torn about the left knee joint. Following her return to her home, she was unable to walk, and she remained in bed for seven months. After this she began to sit up in a chair, and gradually with the aid of a crutch and cane began to walk about. She then began a series of treatments at a hospital, which consisted largely of physiotherapy. The deformity and disability of the left knee was not improved, so she then sought treatment elsewhere, and eventually came under my observation.

Examination, November 19, 1930: This patient is a white female, thirty-six years of age, weighing 185 pounds. She walks with great difficulty, supporting herself with the aid of a cane. Very little weight is borne upon the left knee. The left knee joint appears swollen and the conformation distorted. Active extension is painful, but passively the knee may be extended beyond the usual 180 degrees, and when the leg is allowed to fall in the examining hand, hyperextension to 200 degrees may be obtained. There is lateral instability, and the knee may be moved from side to side as though the joint were very loose. There is normally the tendency to genu valgum, which is also present in the right knee. It is noted that the patella is not in its normal position, in mid-line, but is to be found on the lateral aspect of the joint, above the external condyle of the femur. Any attempt to draw the patella down into position is uneffi-

FIG. 1. A. Patella shown on lateral aspect of knee joint. Lateral to external condyle of femur.

cacious. Flexion of the knee is possible to 90 degrees.

An *x*-ray examination made November 21, 1930, showed the knee in a fully extended position, with the patella situated anterior and external to the condyle of the femur. In the fully flexed position, the patella is pulled to a position external to the external condyle, with its posterior surface in the same plane as that of the external condyle. There is a bony fragment situated anterior and lateral to the external tuberosity of the tibia, and it appears to be attached to the body of the tibia.

Operation, November 21, 1930: An incision was made in the mid-line, parallel with the long axis of the leg, from above the condyles of the femur to the tubercle of the tibia. The patella was found to be dislocated externally and upwards. The ligaments, lying laterally, were incised and it was found that the patella was imbedded in scar tissue. Mobilization was very difficult. It was found that the patella would

* From the service of Dr. S. Kleinberg, Hospital for Joint Diseases, N. Y. C.

FIG. 2. Preoperative *x*-ray. A. Patella. B. Detached tibial tubercle.

FIG. 3. Postoperative *x*-ray. A. Patella now in mid-line, and patellar tendon is shown attached to medial portion of tibia with fragment of bone buried into cortex.

not remain in the position, in mid-line, because of the strong pull of the patellar tendon. The insertion of the patellar tendon into the tibia was lifted out of its bed, together with a small fragment of bone, and this transplanted medially into the tibia, by making a trap door for it. The scar tissue under the patella was then dissected free and the patella finally sutured into mid-line. A bony fragment found lying loose on the medial aspect of the tuberosity of the tibia was removed. A piece of fascia was dissected free on the medial aspect and this was sewed to the patellar tendon. The periosteum of the tibia was approximated by strong kangaroo tendon sutures. Additional sutures were placed on the medial aspect to hold the lateral expansion attached to the patellar tendon. Closure in layers. Plaster-of-Paris bandage applied from the groin to the ankle, holding the knee in extension.

The patient made an uneventful recovery, and at the end of the third week, when the plaster was removed, she was able to flex the knee and extend it through a range of 15 degrees actively.

An *x*-ray examination made postoperatively showed the patella in mid-line between the condyles of the femur, and the transplanted patellar tendon in position in the medial aspect of the upper tibial shaft. The fragment of bone noted on the previous *x*-ray was no longer present.

At the end of one month from the time of the operation, the patient was able to extend the knee completely, and to flex the knee to about 150 degrees. She was fitted with a double upright caliper brace. At the end of two months she was able to walk very satisfactorily, without the aid of crutches, and with the brace adjusted so as to permit flexion at the knee joint.

At the end of four months the brace was discarded, physiotherapy was instituted, and the patient was able to walk very satisfactorily, supporting herself only with the aid of a cane. She was able to completely extend the knee actively, and to flex it to 90 degrees.

At the end of one year from the time of the operation, the patient was able to walk very satisfactorily, using no support. She was able to completely extend the knee actively, and to flex it to 70 degrees. The patella was still in mid-line. There was no pain on motion, but when the joint was palpated during motion crepitation was felt. The patient is now able to walk up and down stairs, and can use her knee in a perfectly normal manner without the aid of any support.

CONCLUSION OF DR. KILLIAN'S ARTICLE*

Chart VI: In this experiment we have observed the influence upon motility of the addition of acid and basic compounds. The graph represents the range of the reactions of the added solutions. Because of the wide range of these reactions it has been necessary to construct the chart allowing equal distances between the whole numbers for pH. This gives the graph a plateau-like appearance, which is incorrect. If the chart were properly constructed the curves would rise to a peak near neutrality, and then fall.

The addition of solutions having reactions varying from pH 5.0 to pH 8.0 have no influence upon the motility of spermatozoa. Solutions more acid than pH of 5 depressed motility, the maximum effect being observed at a pH of 3. The addition of alkaline solutions of pH greater than 8.0 similarly depressed motility of spermatozoa, the maximum effect being observed at a pH of 11.0.

On the basis of these experiments we have suggested to the urologists the use of a medium containing 0.5 molar glucose buffered by phosphates between 7.4 and 7.8 for the maintenance of the motility of spermatozoa.

* Continued from p. 79.

SIMPLE ROTARY LUXATION OF THE ATLAS*

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LUXATIONS of the cervical vertebrae in the atlanto-axial region are fortunately uncommon, and are, sad to state, occasionally not recognized either clinically or roentgenologically. The senior writer has had the occasion to examine patients presenting clinical manifestations of upper cervical traumatic pathology with negative roentgen findings.

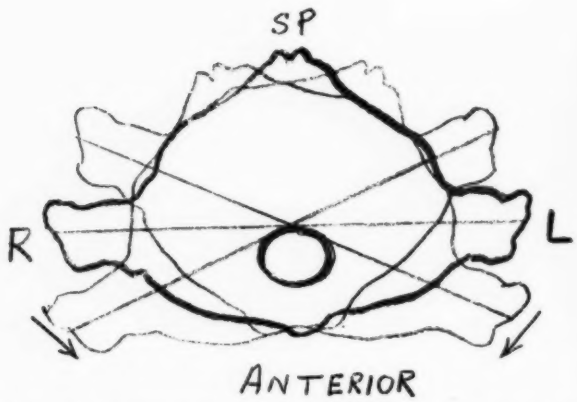

FIG. 1. Diagramatic representation of changes in position of atlas in simple rotation.

This negative observation will be readily understood by those familiar with the perplexing shadows cast by the overriding of the occipital bone, superior maxilla, and the upper two cervical vertebrae. Furthermore, patients in extreme discomfort due to pain and limited motion cannot very well cooperate for the roentgen examination.

Minor dislocations produced with dried specimens and then radiographed revealed such slight deviations from normal that their recognition in vivo seemed doubtful.

TYPES OF DISLOCATIONS

There are three types of dislocations possible at the atlanto-axial joint, namely: (1) right or left lateral; (2) right or left rotary; (3) anterior luxation of the atlas.

Posterior luxation of the atlas is impossible on account of the odontoid process which is closely approximated to the posterior surface of the arch of the first cervical vertebra.

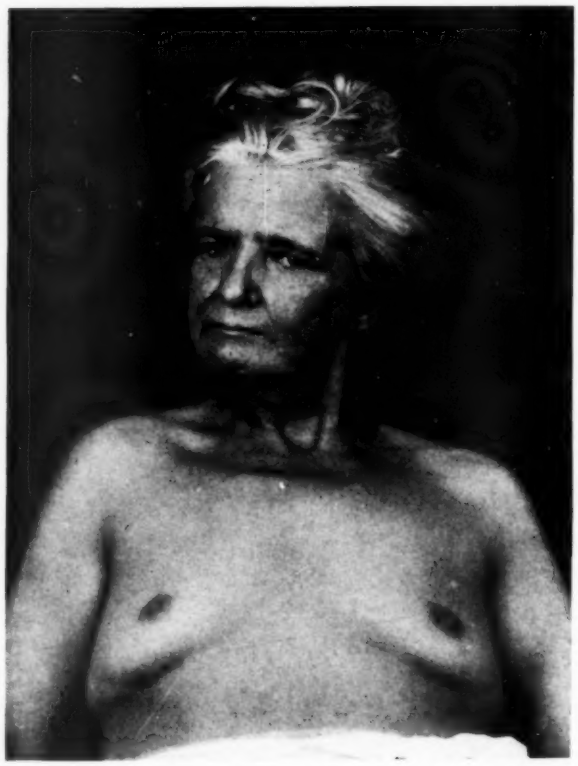

FIG. 2. Female, aged fifty, showing position of head in simple right rotary luxation of atlas.

These dislocations, however, vary greatly in latitude, and on some occasions the lateral luxation may be complicated by slight atlantal rotation. In the case reported here, the condition presented all manifestations of the right rotary luxation, signifying that the atlas was rotated on its axis from left to right. The lateral process of the left side comes forward while that on the right extends backward. A rotary luxation without lateral displacement is very unusual.

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A. C., aged fifty-one, was admitted to Bellevue Hospital on October 7, 1930. Her chief complaint was the inability to turn her head

Fig. 3. Copy of radiograph (retouched) showing diminution in intervertebral space on left and narrowing of space between odontoid process and atlas.

in any direction. She also had severe pain along the right side of the neck and head.

Present Illness. The present illness began on the afternoon of October 4, 1930, after the patient awaked from a drunken spree. She recalled being maltreated by her husband but did not realize her condition until the inebriation wore off.

Physical Examination. Elderly white female sitting in bed with her face turned somewhat to the right and supporting her head with both hands. Her head could not be turned in any direction due to extreme pain in the neck. On attempting to turn the head, the patient experienced excruciating pain along the whole cervical spine. Examination of the eyes, nose, ears, mouth, lungs, and heart revealed unimportant findings. The nervous system did not reveal any neurological signs.

Special Examination. Further examination by the neurologist did not elicit any special findings with the exception of tenderness over the neck and the inability to rotate the head which was found fixed. The orthopedist expressed his opinion after examination that there was a dislocation of the atlas upon the axis without signs of central nervous system injury. "Because of the age of the patient, and her poor physical condition (alcoholic) attempts at reduction are probably not advisable." The application of a Thomas collar was suggested.

Fig. 4. Diagrammatic representation of radiographic findings in simple rotation. Anterior view.

As previously stated, the roentgen findings of atlanto-axial dislocation are often missed and frequently difficult to recognize on account of the superimposed parts. The salient features in simple rotation are a marked diminution of the intervertebral space on one side of the mid-line and the asymmetry in the relation of the odontoid process to the atlas. A minimal amount of lateral luxation[1] is also probably present and is in fact suggested by the eccentric situation of the odontoid process.

These roentgen findings can be readily seen in the anteroposterior position. The lateral view does not show any deviation from the normal in most types of dislocation, with the exception of anterior displacement[2] of the atlas.

RESUME

A case of simple rotation of the atlas is here reported and has not, to our knowledge, been previously described.

Rotation of the atlas is an unusual injury.

The clinical diagnosis of the atlanto-axial dislocation is made symptomatically but the recognition of the type of luxation can only be made radiographically.

[1] Foxe, A. N., and Friedman, L. J. Simple lateral luxation of the atlas. Am. J. Surg., n. s. 8: 831, 1930.

[2] Berkheiser, E. J., and Seidler, F. Nontraumatic dislocations of the atlanto-axial joint. *J. A. M. A.*, 96: 517, 1931.

SUPPORTIVE TREATMENT OF BONE AND JOINT DISEASE*

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THE biological aphorism, ontogeny recapitulates phylogeny, is somewhat applicable to the evolution of the treatment of diseases of bones and joints. Precedented by the experience of the older departments of medicine and surgery from which it evolved, orthopedic surgery has vascillated between extreme conservatism and a program of early and frequent surgical interference. From an ever-increasing experience standardized methods of treatment are being developed.

From the exponents of conservative treatment, notably Rollier[1] and LoGrasso,[2] and the seasoned clinical experiences of Allison,[3] Hibbs[4] and their associates, there has resulted an appreciation of the fact that many lesions of bones and joints are merely local manifestations of general systemic disease processes. The clinical and experimental investigations of Wyatt,[5] Hess,[6] and their associates serve to emphasize this fact as do the notable contributions of recent years that have come through the agencies of preventive medicine. To this the lower incidence of rickets and tuberculosis of bones and joints bears witness and serves to emphasize the importance of supportive health measures in the treatment as well as the prevention of disease. Allison[7] states: "Tuberculosis is now recognized as a disease which must be fought by raising the powers of resistance to the highest possible level in the infected individual."

Surgical treatment was a natural step in evolution with the development of aseptic operative technique. The results of the early attempts to accomplish prompt eradication of bone and joint tuberculosis by complete or partial excision were quite discouraging and gave way to treatment by immobilization in casts and braces. Observations of large series of cases over long periods of time brought forth two important facts: that tuberculous joints without surgical interference show little tendency to heal (activity may persist, though relatively quiescent, for as long as thirty years) and when nature effects a cure, the joint is usually firmly ankylosed. Deductive reasoning resulted in the adoption and application of this principle of complete immobilization in the operation of fusion or arthrodesis of tuberculous joints.

The present-day concept of the treatment of tuberculosis of bones and joints, to quote Allison,[7] "depends entirely upon the realization that the local disease process is of secondary importance and that the treatment of the individual is the matter of prime consideration." He feels that surgical intervention (excision and arthrodesis) should be considered merely an adjunct but a very valuable and important adjunct to general supportive treatment. Likewise, to secure tissue and cultures for the establishment of a positive diagnosis, exploration has an almost universal indication in accessible locations. Numerous reports (Hibbs,[8] Albee,[9] and Allison[10]) of clinical observations have definitely established the advantages of absolute immobilization by bony fusion secured by operation in the prevention of extension and in the promotion of rapid healing. With this concept it has been our policy to carry on months of intensive preoperative and six to eighteen months of postoperative supportive treatment as will be outlined subsequently.

In the treatment of pyogenic infections of bone and joints, the local lesions assume more importance and the demand for surgical intervention is more imperative.

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However, a general health-giving regime affords valuable assistance. The significance of these therapeutic measures in rickets, proliferative arthritis (Still's disease), and the osteochondritides is universally recognized. Supportive treatment in our hands has consisted of:

1. Absolute bed rest or (the ambulatory cases) limited activity with long rest periods during the day.
2. High caloric and high vitamin diet supervised by the department of pediatrics.
3. Fresh air in open pavillions and on the sun roofs, daily in winter and summer.
4. Heliotherapy daily in the open. On dark stormy days irradiation provided by large carbon arc lamps. Graded exposure of entire body.
5. Blood transfusions and iron therapy as indicated.
6. Physiotherapy: breathing and muscle training exercises.
7. Cod liver oil: daily routine.
8. Education: standard courses of instruction are carried out whenever possible.
9. Occupational therapy and recreation receive considerable attention.
10. Immunization to smallpox and diphtheria.

These children rapidly acquire a marked tan and thermal tolerance to heat and cold. The improvement in appetite, gain in w ight and resistance to intercurrent infections are very striking. Upper respiratory infections almost never occur.

This program has been made possible by the full utilization of the facilities of a completely equipped orthopaedic hospital and an associated country home for convalescent crippled children (Figs. 1, 2).

With few exceptions all patients receive their preoperative care (varying from a few weeks to several months) and their postoperative treatment (six weeks to six months in bed and six months to two years ambulatory) at the convalescent home. They are transferred to the orthopedic hospital for operation and immediate convalescence.

The marked objective and subjective improvement (Fig. 3) observed in our cases led to an investigation of the coexisting changes in the blood chemistry and cytology.

CHANGES IN BLOOD CHEMISTRY AND CYTOLOGY

The extensive clinical and experimental investigation in recent years of the influence of heliotherapy in the form of artificial and solar radiation and of vitamin-containing foods (especially cod liver and viosterol) upon animal life in health and disease has resulted in the accumulation of a voluminous literature. The whole subject has been well reviewed by Clauson[11] and Laurens[12] and it is quite apparent that the early unwarranted overenthusiasm has gradually become rationalized and definite limitations established.

Except in the well-recognized deficiency diseases such as rickets, the effect of heliotherapy upon blood chemistry in surgical bone and joint disease has received very little attention. Aschenheim and Meyer[13] studied 16 children with tuberculosis, rickets, anemia, myocarditis, or in health, and found that after irradiation they all showed an activation and an increase of most of the blood cellular constituents. They observed a marked rise in the hemoglobin content and number of red blood cells; the greatest elevations occurring in cases with marked secondary anemia. The quartz mercury lamp and sunlight apparently were equally effective.

In 42 of the 49 cases of pulmonary tuberculosis studied by Lo Grasso and Balderrey,[14] there was an average increase in hemoglobin of 10 per cent following solar irradiation. In 15 similar cases treated with carbon arc radiation, Balderrey and Ewald[15] were able to show an increase in hemoglobin of 67 per cent; in red blood cells of 50 per cent; in lymphocytes of 50 per cent; and in leucocytes of 17 per cent.

Riedel[16] treated 48 cases of surgical tuberculosis and rickets with combined

solar and quartz-mercury lamp radiation. In all cases the hemoglobin, and in 70 per cent of the series, the red blood cells

Fig. 1. Sunporch at country home. Group of patients with tuberculosis of spine receiving daily exposure to fresh air and sun skylight. Note hyperextension plaster beds; exposure of entire body; and high degree of skin pigmentation.

were definitely increased. In very anemic cases the hemoglobin was elevated as much as 34 per cent.

Hoeffel and Lyons[17] studied a large series of cases (mainly surgical tuberculosis) and observed an appreciable increase in hemoglobin and red blood cells only in cases with a definite deficiency in these elements. Skylight appeared to be as effective as direct sunlight.

In our investigation 12 consecutive cases were selected upon admission to the convalescent home and periodic studies were made over an interval of five summer months. The results of this investigation have been compiled in Chart I.

This group of children consisted of 6 cases of bone and joint tuberculosis, one of osteomyelitis of the femur, 2 of proliferative arthritis, one of coxa plana juvenilis, and 2 cases of rickets (one healed and one active). With one exception (Case VII) all cases showed a definite increase in the product of calcium and phosphorus content. Consistent with expectation the most distinct elevation occurred in the presence of the deficiency disease, active rickets. In every instance the phosphorus content increased although not all of the gains were maintained. Neither the carbon dioxide nor the hydrogen-ion content of the blood varied consistently.

The changes occurring in the cellular elements of the blood during this period

CHART I

Case	Observations	Blood Chemistry					Blood Cytology						Weight	Comments
		Ca	P	CO_2	pH	Ca × P	Hgb (Per Cent)	R.B.C.	W.B.C.	P.	L.	MN	Eos	
1. R. S. 13 yrs. Tuberculosis of hip	4–20–31	10.95	4.42	52.45	7.46	48.40	80	4,328,000	22,050	71	15	3	1	In a cast
	5–13–31	11.50	4.94	50.25	7.47	56.81								43.0 kg.
	7–14–31	11.23	4.57	51.13	7.58	50.32								
	9– 3–31	12.80	4.68	49.89	7.40	59.90	88	4,900,000	18,000	68	25	2	2	44.5 kg.
2. C. W. 6 yrs. Active rickets	4–20–31	10.40	2.68	48.00	7.63	37.91	58	4,100,000	8,500	56	30	14	0	14.25 kg.
	6– 5–31	10.92	2.40	46.32	7.57	26.07								
	7–14–31	10.30	3.80	44.40	7.35	39.14								
	9– 3–31	12.00	4.68	47.38	7.42	56.00	78	5,850,000	7,200	62	28	6	1	21.0 kg.
3. T. K. 13 yrs. Tuberculosis of hip	4–29–31	10.89	3.40	53.87	7.41	37.02	65	4,650,000	12,800	68	32	0	0	In a cast
	5–17–31	11.44	4.76	48.54	7.52	54.45								
	9– 3–31	9.50	7.40	47.20	6.95	70.30	85	5,200,000	13,200	65	33	2	1	
4. A. H. 3 yrs. Inactive rickets	4–29–31	11.20	5.92	41.20	7.56	66.20	82	5,100,000	9,300	74	22	2	2	14.0 kg.
	6– 5–31	11.25	7.98			89.77								
	9– 3–31	9.50	9.20	42.80	7.19	87.40	85	5,400,000	8,200	76	22	1	1	14.25 kg.
5. A. I. 12 yrs. Tuberculosis of hip	4–23–31	10.83	4.60	59.30	7.56	49.81	85	5,250,000	10,600	62	38	0	0	In a cast
	6– 5–31	11.10	5.26	52.60	7.56	58.38								
	8–20–31	10.60	5.22	56.04	7.58	55.43	85	5,300,000	9,200	68	28	3	0	
6. P. P. 13 yrs. Osteomyelitis of femur	4–29–31	10.50	5.26	57.80	7.50	55.23	50	4,100,000	26,800					31.0 kg.
	6– 7–31	12.60	4.64	58.50	7.38	58.46								
	9– 3–31	10.05	6.98	55.50	7.39	70.15	78	5,550,000	9,500					34.5 kg.
7. W. B. 13 yrs. Still's disease	5– 9–31	11.66	5.37	51.78	7.22	62.61	80	4,800,000	6,400	67	33	0	0	25.0 kg.
	6–28–31	11.44	5.80	51.28	7.44	67.95								
	8–20–31	10.75	5.30	52.25	7.56	56.97	87	5,100,000	7,200	69	30	1	0	27.0 kg.
8. G. S. 8 yrs. Legg-Perthes' disease	5– 9–31	10.60	4.70	55.03	7.45	49.82	90	5,020,000	7,800	72	26	2	0	21.5 kg.
	8–20–31	10.50	4.99	56.01	7.60	52.39	90	5,400,000	7,200	76	21	3	0	24.0 kg.
9. R. B. 12 yrs. Still's disease	5– 9–31	11.45	4.40	53.52	7.23	50.38	72	4,600,000	6,400	67	32	0	0	21.5 kg.
	6–28–31	10.44	4.73	48.36	7.32	49.38								
	8–26–31	11.10	4.60			51.06	82	4,900,000	6,600	60	24	3	1	18.5 kg.
10. I. S. 5 yrs. Tuberculosis of knee	5– 9–31	10.80	5.55	49.56	7.22	59.94	60	4,250,000	12,200	62	35	2	1	In a cast
	6–28–31	10.70	5.63	49.63		60.24								
	8–20–31	10.64	6.13	53.59	7.58	65.22	85	5,200,000	14,000					
11. E. G. 8 yrs. Tuberculosis of hip	5– 9–31	10.44	5.76	50.36	7.18	60.13	78	4,850,000	9,200	68	32	0	0	In a cast
	6–28–31	11.24	6.15	52.10	7.49	69.12								
	8–20–31	11.10	6.20			68.82	82	5,020,000	8,800					
12 M. G. 11 yrs. Tuberculosis of hip	5–21–31	10.10	4.58	52.19	7.54	46.25	85	5,010,000	17,200	73	25	1	1	In a cast
	7–14–31	10.40	4.78	53.02	7.45	49.80								
	8–20–31	10.72	5.30	50.38	7.36	56.81	85	5,200,000	12,000					

Operation 2–9–31. Extraarticular fusion of hip joint. *X*-ray and clinical evidence of fusion six months after operation. Definite improvement in general appearance.

Malnutrition and very active rickets with marked deformities. Phosphorized cod liver oil administered in large doses. In five months clinically healed rickets.

Bone and joint tuberculosis for eight years with persistent activity of disease. General health markedly improved after five months of treatment.

Healed in child in good general condition on admission. No noteworthy change.

Operation 4–2–31. Extraarticular fusion of hip joint. *X*-ray and clinical fusion in five months and marked improvement in general appearance of health.

Operation 4–8–31. Partial ostectomy of femur. Improvement in general health paralleled gain in weight and improvement in blood picture.

Improvement in general health and nutrition was striking. Active arthritis likewise became quiescent.

Improvement in appearance resembled that observed in children returning from a summer camp.

Active proliferative arthritis which progressed despite treatment with loss in weight, reduction of hemoglobin, and failing in general health.

Operation 4–13–31. Arthrodesis of knee. Child's improvement has been quite spectacular.

Operation 3–9–31. Extraarticular arthrodesis of hip joint. Clinical and *x*-ray evidence of fusion in five months. Convalescence very satisfactory.

Operation 3–27–31. Extraarticular arthrodesis of hip joint. On admission patient's general condition was very good. There has been some improvement in general appearance.

are very impressive. All cases showed a definite increase in the percentage of hemoglobin and in the number of red blood cells. The greatest elevation was observed in the 4 cases presenting the most marked initial anemia. The highest white blood cell count, 26,000, was noted in the one case of chronic osteomyelitis, while the lowest counts, 6400, were found in the 2 cases of proliferative arthritis. With the exception of Cases III and X the change in white blood cells was definitely in the direction of a more acceptable normal.

The striking improvement in general health observed in these cases was due not only to heliotherapy but also to a full, well-balanced diet, constant exposure to fresh air and, in most of the cases, to bed rest.

FIG. 2. Open roof at orthopedic hospital where children receive fresh air and heliotherapy during early period of their convalescence from operation.

COMMENT

Unquestionably the greatest contribution to the treatment of diseases of bone and joints in the future will come through the avenues of disease prevention, and, the disease once established, its early recognition and eradication. We must view tuberculous bone and joint lesions as local manifestations of a general disease, osteomyelitis and proliferative arthritis as primarily metastatic lesions and rickets as a metabolic disturbance in children with low vital reserve, diseases for which the proper treatment assumes much broader proportions than that directed to the involved bones or joints.

An example illustrative of this contention may be cited. Under treatment at the present time at the convalescent home there are 24 cases of tuberculosis of the spine which, prior to admission, were treated as ambulatory patients in plaster jackets. In each instance the disease process has progressed, the deformity increased, and the general health and nutrition failed. Sixteen cases had large

psoas abscesses with discharging sinuses and 3 cases had extensive amyloidosis.

After several months of absolute bed rest in hyperextension plaster beds, constant exposure to fresh air, daily heliotherapy and high caloric and vitamin food intakes, the local and general improvement in each instance was most gratifying. As a supplementary therapeutic measure the diseased portion of the spine in each case was osteosynthesized by the Hibbs-Allison[18] operation with anchorage upon two uninvolved vertebrae above and two below the diseased bodies. The resultant absolute immobilization may be expected to aid and hasten the process of healing but in no sense can it be considered a cure in itself. The patients still have active tuberculosis of the spine. For this reason diligent supportive treatment is resumed after operation and continued for at least one year after there is *x*-ray evidence of complete fusion and healing of the diseased vertebral bodies (a total period varying from eighteen months to two years).

CONCLUSION

Evidence has been presented of the improvement in general health as a result of adequate supportive treatment, not only in general appearance but in the blood pictures and weight charts, of 12 cases of bone and joint disease studied over a period of five months.

Excision of joints with subsequent fusion and other operative procedures in diseases of the osseous system should be preceded and followed by long periods of rest, heliotherapy, diet and similar measures intended to strengthen the general reparative processes and to improve the health of the organism as a whole.

Fig. 3. Child, aged six years, with tuberculosis of lumbodorsal spine and psoas abscess with discharging sinus. Gain in weight, strength and tissue turgor after nine months of supportive treatment, supplemented by spinal fusion, is quite striking. Note decrease in kyphos; also marked sun tan.

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DIAPHRAGMATIC HERNIA

REPORT OF A TRAUMATIC CASE*

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THE stages of surgical evolution have, in most common operations, developed an almost standard technique which is the basis around which different surgeons build their personal variations. This array of fine points of difference most frequently determine the different operations. Such, however, is not the case in dealing with diaphragmatic herniae. There seems to be no authoritative procedure from which we lead.

The pathology will vary accordingly as the lesion is congenital, acquired or traumatic. Most herniae occur on the left side, the cause being self evident in the light of the anatomical arrangement. The diaphragm is more ligamentous on the right, and more muscular on the left. The liver practically fills the dome on the right side thus forming an efficient tamponade of this region, while the left side has no such abdominal organ and is thus vulnerable to traumatic lesions. The foramen of the vena cava, the hiatus of the esophagus or the Aorta are naturally the most frequent sites for congenital and acquired lesions, and probably for traumatic ones. Traumatic herniae being also the result of actual rupture of the entire thickness of the diaphragm. The congenital herniae usually exist at one of the natural openings due to failure in the fusion of the different parts and thus have no sac. The acquired type, as in inguinal herniae, has a double walled sac with an inner layer of peritoneum and an outer one of diaphragmatic pleura. In traumatic herniae there may be a muscle rupture with the production of a sac as in the acquired type already described, or most often there is a tear of all the tissues of the diaphragm with no sac present and the abdominal contents are free in the chest cavity. Hedblom in an analysis of 378 cases found that two-thirds were traumatic in origin, one-sixth congenital, and one-sixth acquired, while Lacher in analyzing 276 cases found 85 per cent to be left sided.

The symptomatology of this condition can probably be best presented by dividing it into two types, viz. early and late. The early symptoms upon which one might expect to base a conclusion are in the chest: cyanosis, dyspnea, limitation of chest expansion on the affected side, pain in the top of the shoulder, dextrocardia, absence of fremitus, increased resonance, absence of breath sounds, and gurgling sounds due to gastrointestinal gas. In the abdomen one usually finds pain of moderate degree, muscular rigidity rather severe and most marked on the affected side. The ultimate criterion for definite conclusions is the *x*-ray showing of abdominal viscera with their gas in the chest cavity, absence of lung tissue with its air and lung markings, and finally the barium outline of the gastrointestinal tract within the chest cavity.

The late signs of pathology are less acute and one finds usually only dextrocardia in the chest, and varying degrees of indigestion and intestinal obstruction in the abdominal viscera.

The treatment of diaphragmatic herniae is entirely surgical, and Lacher's report of a mortality of 72 per cent of 36 traumatic cases not submitted to operation is sufficient to justify its use in all cases.

The operative approach may be thoracic, abdominal, or a combination of these two. And here it would seem is where no master

mind has produced a standard technique which meets the logical requirements of mechanics, anatomy, and physiology.

THORACIC ROUTE

The thoracic approach is best for a repair of the diaphragmatic defect; it produces probably 50 per cent less shock and mortality, allows exploration of injuries to the lung, heart and pericardium and permits reexpansion of the lung when the operation is finished. It produces, however, a more massive collapse of the lung on the affected side, a "flapping" mediastinum, and an embarrassed function of the opposite lung—all of which must be recognized as actual complications if we would continue to improve our results. Again this approach does not give all that we might wish in breaking up adhesions in old cases, and in relieving a strangulation in a more recent one.

ABDOMINAL ROUTE

For an exploration of a strangulation or a perforated viscus this approach is certainly essential. With it old intrathoracic adhesion, old or new inflammatory exudates cannot be safely broken up. But the most important factor against its use is the marked difficulty experienced in closing the rent in the diaphragm and the shock of this strenuous manipulation. This, in our mind is what leads to such poor results, and is the basis of Neugebauer's report in Bennie's Surgery of a mortality of 100 per cent by the abdominal approach in strangulated cases. Here we dare not pull strongly enough to force an incarcerated viscus from the chest back into the abdomen, just as we dare not push this strenuously when operating by the thoracic approach.

COMBINED THORACIC-ABDOMINAL ROUTE

We feel that this method eliminates the disadvantages and hazards of both the foregoing in so far as is possible without adding anything in danger, trauma or manipulation. On the other hand it has all the good points of both routes, is much less difficult and largely removes the shock of the abdominal route. The technique which we conceive as being most anatomical and physiological is sufficiently explained in the attached case report.

CASE REPORT

History: R. G., female, white, aged twenty-one, housewife having one child two years old with irrelevant family and personal history. On May 13, 1931, while riding in an automobile patient collided with a street car and was thrown out, striking the curb. She was unconscious for a few hours after which she showed slight cyanosis, slight dyspnea, with pain in the left chest about the sixth to ninth ribs midaxillary, with considerable pain in the top of the left shoulder. On inspection, the left chest did not show the normal expansion, but seemed rather completely fixed; on palpation the normal fremitus was conspicuously absent; on percussion there was a hyper-resonant note indicating excessive gas in the chest cavity, and the cardiac area of dullness was displaced almost completely to the right of the midsternum; on oscultation the gurgling of gas in some abdominal viscus could be very plainly heard up to about the second rib on the left.

With these symptoms only one finding could be anticipated and that an abdominal viscus within the chest cavity. *X*-ray on May 14, 1931 showed the left lung almost completely collapsed, the heart displaced far to the right of the midline of the chest and the left chest containing gas with a shape indicative of some abdominal viscus. Barium meal was given and a second film showed the stomach greatly distended and reaching up to the second rib.

A diagnosis of traumatic diaphragmatic hernia was made and operation was done. The patient was given nitrous oxide-oxygen anesthesia under positive pressure with the mask tied firmly over the face so as to control accurately the intrapulmonary pressure with the pressure of the gas tank and the valve of the mask.

An incision was made 8 inches long beginning in the mid-axillary line on the left in the seventh interspace, running forward and down-

ward across the costal margin on to the abdomen. The abdomen was opened for 3½ inches, the chest was opened, the costal cartilage was cut and a rib spreader was put in to widen the intercostal space. At this stage the anesthetic pressure was lowered to allow the left lung to remain out of the operative field. About the middle of the vault of the left dome of the diaphragm, there was a fresh linear tear about 6½ inches long and through this we found almost the entire stomach, which was greatly distended with gas, practically all the omentum, transverse colon, the entire spleen and several feet of small intestine. With one hand in each cavity the viscera were returned to the abdomen. Then through the chest opening, the rent in the diaphragm was very easily closed with a double layer of continuous chromic No. 2 catgut. The abdomen was then closed and then the chest. The chest could only be approximated by using pericostal catgut sutures with a continuous suture of the pleura and intercostal muscles. As the chest was being closed the pressure in the anesthetic mask was increased, ballooning up the collapsed left lung to fill the chest cavity, the last stitch closing the opening just as the last intrathoracic air was expelled. The muscle, fascia and skin were closed as usual without drainage.

Pressure from strangulation in the diaphragmatic rent had produced an area of beginning necrosis in one area of the stomach wall but no resection was necessary. There was no shock from the operative procedure, the patient recovering consciousness on the table, and she seemed to be in better condition immediately after operation than before, the pulse having reached 120 before operation.

She made an uneventful recovery and *x*-ray of the chest two days after operation showed the heart in normal position and the left lung filling the left thoracic cavity normally. She left the hospital on the ninth day and has since been normal in every way.

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INTRAGASTRIC POLYPUS

REPORT OF CASE*

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BENIGN pedunculated intragastric polypus falls under the rarer classification of stomach tumors. Especially is this true when the pedunculated mass assumes the size of that in the case to be reported. Because of its relatively infrequent occurrence, this patient with her history, operative record and postoperative observation is presented for consideration.

FIG. 1. Polypus, showing ulcer.

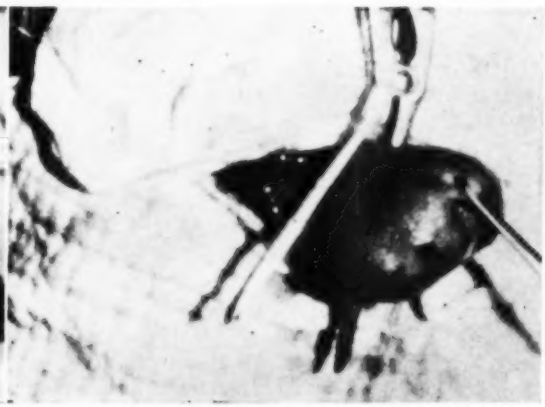

FIG. 2. Crushing clamp applied to pedicle of polypus.

In 1921 Eusterman made an exhaustive statistical review of benign tumors of the stomach. His conclusions showed carcinoma to be 200 times more frequent than benign tumor. This study included all benign growths, myomas, fibromas, angiomas, dermoids, as well as single polypus of the stomach.

Pedunculated myoma or fibroma is usually seen in the middle or pyloric portion of the stomach, attached to the posterior or anterior wall. Of unknown etiology, these pedunculated, freely movable tumors within a hollow muscular viscus are subject to mechanical disturbance. This interference may affect the tumor itself or its containing viscus. Included within the range of possible complications to the stomach is permanent pyloric obstruction, or the tumor may produce the ball-valve type of intermittent closure. Intussusception of the stomach produced by a polypus has been reported. Single polyps may become strangulated or the tumor may undergo malignant degeneration.

The presence of a lone ulcer on the surface of all single intragastric polyps accounts for the symptoms most common to this type of tumor, namely that of gastric-enteric hemorrhage. Persistent occult bleeding, resulting in secondary anemia, is the outstanding clinical manifestation of gastric polyp. Sudden, severe recurrent hemorrhage of an alarming degree is not an infrequent occurrence and many times leads to gastric investigation.

The diagnosis of intragastric polyp rests ultimately with *x*-ray examination or operative exploration.

The treatment depends upon surgical intervention with the excision of the polyp at the base of the pedicle. If examination

* Read before the George Washington University Medical Society, Dec. 19, 1931. Motion pictures of the operative procedure were shown in conjunction with this paper.

at operation discloses evidence of malignancy, resection of the stomach should be considered.

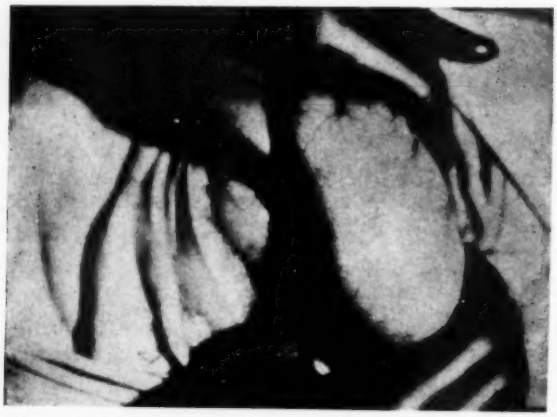

Fig. 3. Stomach containing polypus held between fingers before opening anterior gastric wall.

REPORT OF CASE

H. W. Case No. 53884. Married woman, aged forty-three. Admitted to the ward service at Emergency Hospital, April 12, 1929.

Her family history was negative except that one sister died of hemorrhage of the stomach.

Ten years ago the patient had had a sudden gastric hemorrhage. She had suffered before and since that time with stomach trouble, indigestion and cramp-like pains in the upper abdomen. For many years she had been under a doctor's care for general weakness, dizziness and a ringing in the ears. Two years before, she had had to go to bed because of a heart attack.

Her present illness began the night before admittance to the hospital with nausea and weakness. On the morning of April 12 she vomited blood and passed bright red blood by rectum. The Emergency ambulance was called. During her conveyance to the hospital she had another vomiting spell when a large quantity of blood was lost. Upon admission to the hospital at 12:10 P.M., her temperature was 99.2°F., respirations 26, pulse 80 and very weak. The blood pressure was 114/74. Fifteen hundred cubic centimeters of glucose were given intravenously at once. A transfusion of 500 c.c. was then given and her condition improved. Her blood picture two days later was as follows: Hemoglobin, 37 per cent; R. B. C. 2,160,000; W. B. C. 6500.

Except for abdominal tenderness the physical examination was essentially negative.

Under supportive treatment her condition,

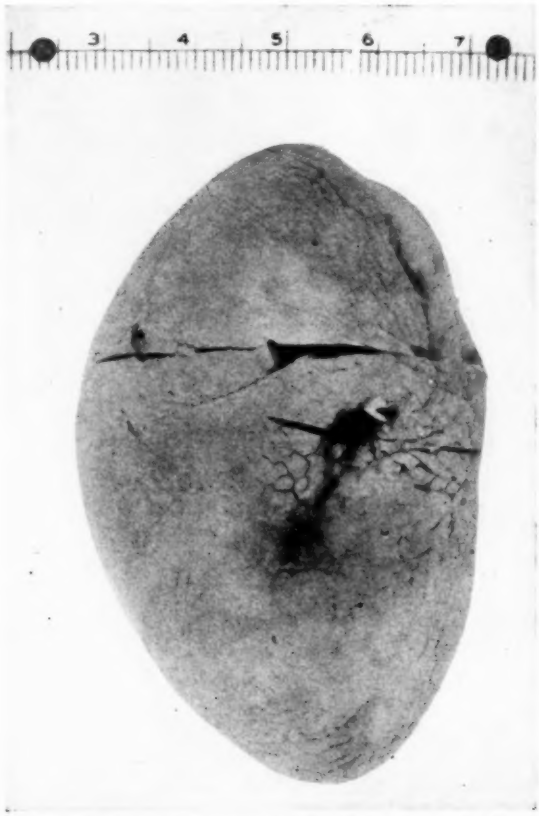

Fig. 4. Tumor removed, showing actual size.

after another transfusion on April 29, 1929, permitted *x*-ray examination, which showed "a large intragastric growth in the distal half of the stomach attached to the inferior margin by a pedicle approximately 2 cm. in length. The growth proper is approximately 6 cm. in diameter and it could be moved upward toward the cardiac end and downward toward the pyloric end of the stomach for a distance equal to the pedicle of the growth. This is thought to represent a large polyp, the size of which would suggest that it is probably undergoing some malignant degeneration. There was no six-hour gastric residue."

On May 1, 1929, through a right rectus incision, the abdomen was explored for evidence of malignancy. There being no evidence of glandular enlargement, an intragastric tumor, pedunculated, the size of a lemon, was removed through an incision in the anterior wall of the stomach. Six days after operation, there developed a respiratory complication with a

slight cough. This was transient and the patient was discharged from the hospital May 24, 1929. Since leaving the hospital, she has worked continually, has had no gastric symptoms and has gained 40 lb. in weight.

Pathological examination disclosed a tumor, "irregularly oval in shape and measuring 7 cm. long, 4.5 cm. wide, and 4 cm. thick. It is a light brown in color and very firm in consistency, except at one portion where it shows evidence of softening. It is practically covered with gastric mucous membrane which is smooth and moderately soft in consistency. The normal rugae have practically disappeared as a result of the upgrowth of the tumor. In the central portion there is a depressed area, irregular in shape which measures 1 × 2 cm. in diameter and at one pole of this area there is a definite ulceration 1 cm. in diameter which extends into the tissue. The ulceration has ragged edges and extends into a cystic or degenerated cavity which contains a dark brown, chocolate colored substance. The under surface of the mass is smooth and glistening and apparently has been attached by a broad pedicle to the walls of the stomach. It appears to be definitely surrounded by a complete fibrous connective tissue capsule."

"Microscopic examination shows the mucous membrane to be markedly thinned, apparently as a result of compression atrophy; this is associated with a relative submucous round cell infiltration except in one portion where definite ulceration has taken place. Immediately beneath this are found atrophic strands of smooth muscle fibers interspersed in various areas with dense bands of fibrous connective tissue, all of which is infiltrated with a relative number of small round cells. In some areas the muscle fibers show definite proliferation.

[Concluded on p. 123.]

Fig. 5. Tumor opened after removal.

Fig. 6. *X*-ray of stomach after operation.

Fig. 7. *X*-ray showing clearly pedunculated tumor within stomach.

PRIMARY CARCINOMA IN THE VERMIFORM APPENDIX*

REPORT OF A CASE

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PRIMARY carcinoma of the vermiform appendix is not rare; over 360 cases have already been collected, and new ones are constantly being reported because most appendices removed at operation are now being examined histologically. According to Sloan primary carcinoma of the appendix is usually discovered incidental to operation, the lesion frequently being diagnosed only after histological examination of the tissue. However, sometimes obstruction of the lumen of the appendix by the tumor may give rise to symptoms of acute appendicitis for which an emergency operation is done.

FIG. 1. Low power view of tumor obstructing lumen of the appendix and penetrating wall. Mag. 12 ×.

In our case there were no symptoms of acute appendicitis and the carcinoma was diagnosed in the microscopical section.

There are two types of neoplasm occurring in the appendix, namely (1) adenocarcinoma and (2) carcinoid. While they are different pathologically, their identities are not clearly indicated in the surgical literature. According to Eli Moschcowitz and others, true adenocarcinoma of the appendix is of low malignancy both pathologically and clinically. The histological picture resembles other intestinal carcinomata only in the alveolar structure, and the epithelial type of cell, but it differs considerably from fully developed intestinal carcinomata by the lack of tendency to invade neighboring structures, and by the fact that the cell type is uniform. The nuclei of the tumor cells in adenocarcinoma of the appendix show very little variation in size and shape. They are less rich in chromatin and

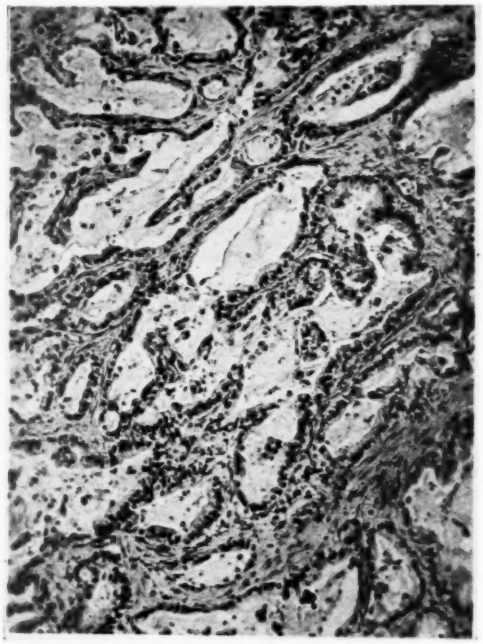

FIG. 2. Detail of gelatinous adenocarcinoma under high power. Mag. 180 ×.

* From the Department of General Surgery, Hospital for Joint Diseases, N. Y. C., Dr. P. M. Grausman, Dir.

are comparatively free from mitotic figures. These appendiceal adenocarcinomata show practically no tendency to metastasize. On the basis of histological appearances Selinger divides them into columnar and gelatinous adenocarcinoma, but this classification is not universally used.

One of the first authentic cases was reported by Berger in 1882. A. V. Moschcowitz, in 1903, collected 18 cases and added 4 of his own. By 1926 about 300 cases had been reported. Selinger added 34 in 1927. We have found 25 cases recorded in the Cumulative Medical Index from 1927 to 1931, which makes a total of about 360 cases recorded in the literature.

The incidence of carcinoma of the appendix varies with the different reports. Kelly and Hurdon state that in 40,738 autopsies made at the Vienna General Hospital between the years of 1870 and 1892, 2 instances of carcinoma of the appendix were found in 343 cases of carcinoma of the digestive tract. Letulle observed carcinoma of the appendix seven times in 800 autopsies. Reiman reported 17 cases in 13,151 appendices routinely examined, or an incidence of 0.13 per cent. McCarthy and McGrath report one adenocarcinoma of the appendix in 225 cases, while Montgomery and Johnson recently reported an incidence of carcinoma of the appendix varing from 0.2 to 0.5 per cent in all appendices removed. They also state that appendiceal carcinoma constitutes less than 0.5 per cent of intestinal carcinomata. The records of our laboratory show that 1390 appendices were examined microscopically from January, 1925 to July, 1930. One instance of true carcinoma of the appendix was observed. Fifty-five gastrointestinal carcinomata are recorded. Thus, according to our records, 0.07 per cent of the appendices show carcinoma, and 1.8 per cent of digestive tract carcinomata occurred in the appendix.

Primary appendiceal carcinoma is said to occur more frequently in females than males, but it must be remembered that females undergo more abdominal operations. Our case happens to be a female. There is considerable variation in the age of reported cases. The youngest patient was reported by McCarthy and McGrath, the patient being five years of age, while Kudo reported the oldest patient, who was ninety-two years of age. Kelly and Hurdon state that the greatest incidence is from twenty to thirty years.

CASE REPORT

Patient M. Z. History No. 19757. Pathological Report No. 3990. Patient is a white female, aged forty-three, native of Bohemia, occupation housewife. She entered the hospital January, 1929, complaining of a mass in the abdomen, backache, and a protrusion from the vagina. The previous history was negative except for menstrual irregularity. There were no complaints referrable to the appendix. The patient has three children living and well. The admission diagnosis was ovarian cyst. The laboratory examinations were negative. At operation an ovary was removed that proved to be a dermoid cyst. The appendix was removed at the time of the pelvic operation.

The appendix measured 6 cm. in length and showed some evidence of involutional atrophy. Near the tip the peritoneal coat was covered with some fibrous adhesions. The section of the appendix near the tip showed thickening of its walls and infiltration of the coats with polymorphonuclear neutrophilic leucocytes, round cells, and eosinophiles. There was a thin layer of fibrin on the peritoneal coat. The underlying basis for the reaction was the extension of a columnar, gelatinous adenocarcinoma of the appendiceal mucosa into the coats of the appendix, and into the lumen of the appendix which was obstructed by the tumor. A section at some distance from the tip showed no carcinoma.

Two years after this the patient was again admitted to the hospital for pelvic repair, and at that time the peritoneal cavity was examined and found to be entirely free of tumor.

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[For Remainder of References see p. 139.]

DUPLICATION OF THE BOWEL*

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THE following case is presented because of the unusual type of anomaly found as well as the clinical interest:

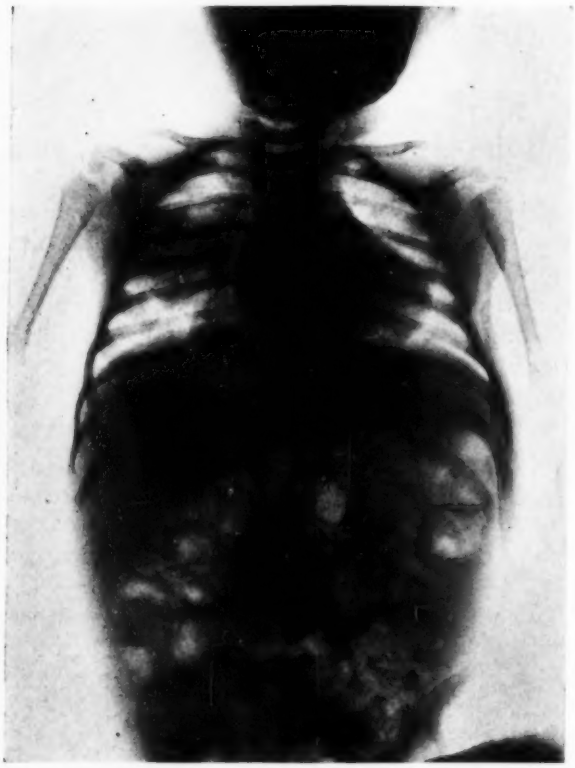

FIG. 1. Radiograph of chest. Note bilobed tumor on right side, lower portion of which is behind shadow of diaphragm.

E. P., a white female infant five months of age, was admitted to the New York Nursery and Child's Hospital in August, 1929, because of bleeding from the rectum. A black stool had been noted two months before. The baby was fairly well nourished but pale. The abdomen was negative except for slight distention. No local cause for hemorrhage was found in the rectum. A gastrointestinal *x*-ray series was negative. The hemoglobin on admission was 61 per cent with 4,300,000 red cells. White count, platelets, bleeding and coagulation time were normal. The stool contained occult blood on repeated examinations. Aside from these observations the condition of the chest was of particular interest. The physical findings

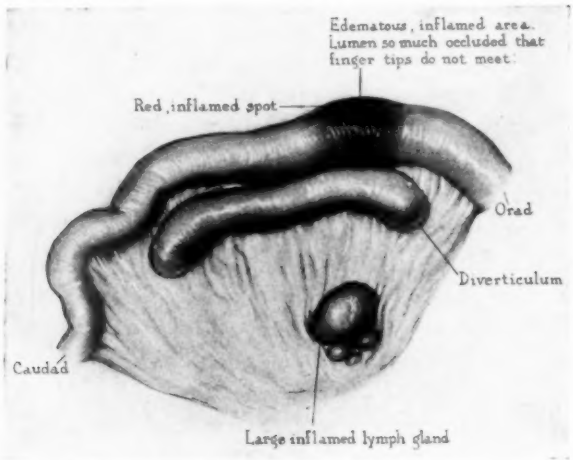

FIG. 2. Drawing of findings at operation.

were dulness and bronchovesicular breathing over the lower two-thirds of the right chest. *X*-ray (Fig. 1) showed a bilobed tumor mass in this region. During this hospital stay the child coughed at intervals and there was a period of fever during which it was thought that there might be some pneumonia about the tumor.

In the succeeding two months she was three times readmitted to the ward because of sharp bleeding which came on with attacks of abdominal pain. A moderate cough persisted. The chest findings remained about the same. In November an exploratory laparotomy was performed. The baby was eight months old at this time.

Operation disclosed an unusual condition (Fig. 2). Lying in the mesentery of the small intestine about midway along its course and closely approximated to it in part was a duplication of the bowel one foot long. Both ends were blind. At the region of close approximation was an omental adhesion. The bowel at this site was markedly inflamed with its lumen much occluded by the swelling. On its anti-

* From the Pediatric Service, New York Nursery and Child's Hospital.
Read before The Brooklyn Pediatric Society, Dec. 16, 1931.

mesenteric side at this area was an appearance identical with that of an active but not yet perforated peptic ulcer of the duodenum. Communication between the diverticulum and the bowel could not be determined as neither was opened. The mesentery draining this area contained large inflamed glands. The bowel proximal to the inflamed area was distended while that distal was contracted showing a considerable degree of obstruction.

Excision would have been the procedure of choice but the baby's condition rendered this too hazardous and an entero-enterostomy was carried out, side-tracking the diseased portion of bowel. It was hoped by this procedure to divert the intestinal current away from the ulcer and therefore favor healing.

The postoperative reaction was sharp, but rapidly subsided and the child made a good surgical recovery. Her general condition improved for a time and she gained weight. There were no more gross hemorrhages although occult blood was found in the stools more often than not.

In January, 1930, two months after operation, at a visit to the dispensary the baby was coughing and vomiting, having a temperature of 105°F. Dulness and high-pitched breath sounds with many course râles were found on the right side. The fifth admission occurred a few days later because of persistence of the acute respiratory condition. She was in the hospital about one week.

The sixth and last admission was in March, four months after operation. The infant had done fairly well until two days before when she grew irritable, cough increased and she became cyanotic alternating with spells of pallor. She was admitted acutely ill with fever and rapid respirations. The pulmonary signs were much as they had been, except for fine crackles. An *x*-ray of the chest (Fig. 3) showed for the first time a marked change in the tumor, the upper lobe of which had shrunk so that it was not recognizable. The child died suddenly that evening. Autopsy was not permitted.

R. H. Fitz[1] wrote in 1884 that most if not all well-authenticated cases of duplication of the intestinal tract are the probable result of persistence of the vitelline duct.

Moll[2] reported a case which in many respects closely resembled ours. At autopsy it was found that the lower ileum presented a double-barrelled appearance due to a loop running upward in the mesentery

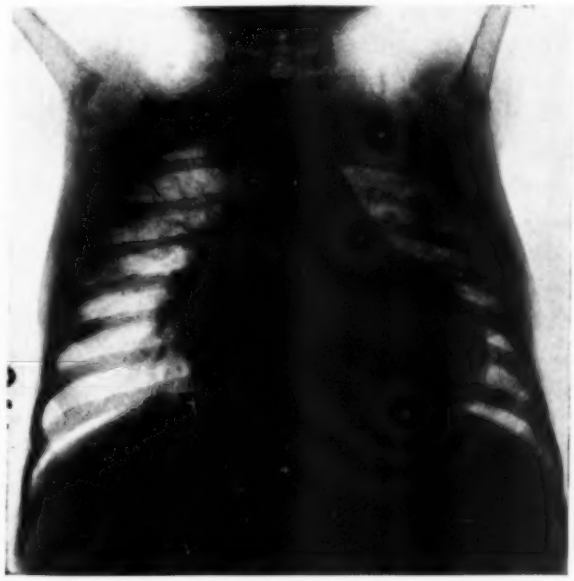

Fig. 3. Radiograph of chest made on day of death. Note that upper portion of tumor seems to have disappeared although lower portion is still present.

for 33½ inches where it ended blindly. Its lower end, contrary to the findings in our case, crossed the ileum and opened into the antimesenteric side of the bowel. Moll considered this to be a Meckel's diverticulum. A "retention cyst" the size of a hen's egg was found in the left pleural cavity.

McMurrich and Tisdall[3] described a remarkable ileal diverticulum in a child thirteen months old, which arose from the intestine 45 cm. above the ileocecal valve, extended upward in the mesentery for 104 cm., half that distance intimately adherent to the bowel, and terminated in a blind sac. The authors suggest as an explanation of the anomaly that it was due to the whole yolk sac being drawn back into the abdominal cavity.

On the other hand not all instances of duplication can be explained as Meckel's diverticulum. In Edwards'[4] case there was a diverticulum 28 inches long originating from the small bowel on the mesenteric side. The first 17 inches ran between

the leaves of the mesentery. It is of particular interest that in this patient a small Meckel's diverticulum arose from the bowel 7 inches from the origin of the large diverticulum. Edwards thinks that the giant diverticula represent an attempt at twin formation. The work of Lewis and Thyng[5] who showed that knob-like intestinal diverticula occur in human embryos as well as those of some lower animals is also quoted as an explanation of the occurrence of congenital diverticula other than Meckel's.

Diverticula presenting the form of intestinal duplication are not confined to the small intestine as witness Wright's[6] case in which it arose from the sigmoid and ran in the sigmoid mesentery for part of its course, ending as a blind retroperitoneal sac.

It is unfortunate that the chest condition in our patient could not have been clarified, especially as the clinical evidence suggests it to have been the cause of the fatal issue. In the case of Moll already mentioned a retention cyst was found in the left chest. He does not describe it further. In an infant dying at birth, reported by Roth,[7] a diverticulum which took the form of an intestinal duplication was present as well as a cyst in the abdomen and another in the chest of intestinal structure. One of us had under his care some years ago a child who died as a result of suppuration in the right chest. At autopsy a duodenal diverticulum was found to pass upward through the aortic opening into the right side of the chest where it was apparently the source of the inflammation. Incidentally this child had a small typical Meckel's diverticulum. Mixter and Clifford[8] reported two instances of mediastinal gastrogenic cysts. These cases suggest that the tumor of the chest in our patient may have been another malformation of alimentary tract origin.

Recent literature has contained many reports of patients in whom intestinal bleeding has been found to originate in an ulcer associated with a Meckel's diverticulum. The analogy of these ulcers to peptic ulcer of the stomach and duodenum would seem to be very close inasmuch as the diverticulum in the circumstance of ulcer formation has been repeatedly found to contain gastric mucosa. Schaetz,[9] who reported his observations on a series of Meckel's diverticula, found gastric mucosa in about 16 per cent. It would therefore appear that in approximately 1 in 6 cases of this anomaly conditions favorable to ulceration exist. Aschner and Karelitz[10] and Greenwald and Steiner[11] have reviewed the subject recently. They found hemorrhage often associated with abdominal pain to be the essential symptom. Perforation is a frequent complication. In almost all cases where an histological examination was included gastric mucosa was found. We have ourselves had a typical instance in a body of five who had been repeatedly hospitalized for severe intestinal bleeding. Perforation occurred while he was being prepared for operation. A small Meckel's diverticulum showing gastric heterotopia was found together with an ulcer in the intestinal mucosa adjacent to the diverticulum.

In view of these facts we feel that there probably was gastric mucosa in the diverticulum in our case of duplication and a connection between it and the bowel. Of the cases of duplication to which we have referred in the discussion the clinical history and findings are significant in this connection. Moll's patient, an infant, was admitted for severe attacks of melena. At the junction of the diverticulum and ileum there were two chronic ulcers. McMurrich and Tisdall's patient, a child of thirteen months, had had black stools before admission. There were oxyntic cells in the diverticulum. Edwards' patient had had hemorrhage and pain from the age of four months to sixteen years when he suffered a perforation in the free portion of the diverticulum. The mucosa of the diverticulum was lined by a layer of columnar mucus secreting cells having the appearance of small intestinal epithelium beneath which was a

closely packed mass of glandular epithelium resembling gastric mucosa. Wright's patient, an adult, with the diverticulum arising from the sigmoid, presented symptoms of chronic obstruction.

Abt and Straus,[12] in a paper calling attention to Meckel's diverticulum as a cause of intestinal hemorrhage, reported 3 cases of which the third presented an intramesenteric diverticulum 18 inches long opening into the ileum at its lower end. It was filled with blood. The lining was intestinal mucosa. No ulcers were observed.

SUMMARY

The case of an infant who suffered repeated attacks of melena and who was found at operation to have a diverticulum in the form of a duplication of the bowel about 12 inches long, with evidence of ulceration in the adjacent small intestine, is described. In addition this patient had a tumor in the right side of the chest which is believed to have led to her death.

In the discussion cases from the literature of diverticulum presenting the form of intestinal duplication wholly or in part are cited; cases are also cited which suggest that the tumor of the chest may have been a diverticulum of alimentary tract origin. The significance of unexplained melena as an indication of congenital intestinal diverticulum with ulcer formation is emphasized.

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CONCLUSION OF DR. BORDEN'S ARTICLE*

The individual cells are swollen and are of about twice the normal size. In these portions the nuclei are large and somewhat hyperchromatic but they do not show evidence of mitosis or malignant infiltration. Occasionally the cells seem to be fused and to have formed pseudo-giant cells. Dense bands of connective tissue also intersperse this area. The central portion of the tumor consists of a degenerated mass in which may be seen growing young fibroblasts which are somewhat vesicular and spindle shaped in form. They do not appear to be of a malignant nature. The tumor as a whole appears to be an intramural leiomyoma which has grown rapidly and undergone a central necrosis and ulceration as a result of a deficient blood supply. No evidence of malignancy was found in any area."

* Continued from p. 117.

DUPLICATION OF THE GALL BLADDER

CASE REPORT WITH A REVIEW OF THE LITERATURE

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ROANOKE, VA.

THE occurrence of two or more gall bladders in the human body was probably first described in medical literature by Blasius in 1674. However, Pliny mentions that on the day of the Emperor Augustus' naval victory at Actium[1] (31 B.C.) a double gall bladder was found in the sacrificial victim. In 1926 E. A. Boyden[2] published an article in which the whole subject of accessory gall bladders was very thoroughly discussed and the literature reviewed to that date. He reported at that time 20 cases obtained from the literature. We are indebted to Dr. Boyden's article for most of the information contained in this discussion.

According to Boyden, aberrant hepatic vesicles can be arranged into four genetical groups, all of which originate early in embryonic life. These groups are, namely, *diverticular* gall bladders (arising from the neck of the embryonic gall bladder); *cleft gall bladders; ductular gall bladders* (from hepatic, cystic, and common bile ducts); and *trabecular gall bladders* (from liver trabeculae bordering the fossa vesicae fellae).

Anomalies of the gall bladder occur much more frequently in some of the lower animals than in man. Boyden found in a study of 2568 cats that accessory gall bladders occurred in 315 or 1 in 8 animals. In calves the proportion is 1 in 28; in sheep 1 in 85; in pigs 1 in 198. Summary of reports of 19,000 autopsies in several anatomical laboratories showed 5 cases of duplication of the gall bladder in the human body, an incidence of 1 in 4000. The most varied anomalies are found in cats, as many as four gall bladders having been found in one animal.

Double gall bladders are also occasionally found in the domestic food animals. In fact, according to the orthodox Jewish law governing the preparation of animals for food, the presence of some of these anomalies renders the animal unfit for use. "In Joseph Caro's 'Shulhan' Aruch,' the final and authoritative codification of the Jewish law, there are nine rules dealing with such contingencies as the absence of the gall bladder, duplication of the gall bladder, and the presence within it of hard structures comparable to the pits of olives and dates." (Boyden.[2])

In man the prevailing type of anomaly is the double gall bladder having two cystic ducts, the accessory vesicle probably arising as an outgrowth of the cystic or common ducts. Of the 20 cases given by Boyden, 17 are of this kind. The truly bilobed vesicles are very rare. Of the more frequent type two smaller divisions can be made, namely, those in which the two cystic ducts unite before entering the common duct (to which the case to be reported belongs), and those in which the vesicles are completely separate and empty separately into the common bile duct.

The case which forms the basis of this report occurred on the service of Dr. Trout at the Jefferson Hospital. Its presence was not suspected or diagnosed before operation.

CASE REPORT

The patient, a housewife of thirty-two, was admitted on October 22, 1931, complaining of "gall bladder trouble." Family history was not significant. She had always been healthy and had previously had no serious illness or operation. About eleven years before admission she had an attack of bronchitis lasting several months. At this time she was pregnant. A few months later she noticed a protrusion in the left inguinal region which gradually developed

into a large inguinal hernia. This had varied in size for the past ten years.

The present illness began two years before admission when she felt a severe pain in the right upper abdomen, which radiated to the back and scapular region. This pain was accompanied by nausea, vomiting, slight jaundice and clay-colored stools. The attack gradually subsided for a week. Thereafter she was subject to similar attacks every few months with increasing frequency.

Physical examination showed nothing of significance except a large left inguinal hernia and some tenderness on deep pressure under the right costal margin anteriorly. The gall bladder could not be visualized by *x*-ray.

She was operated upon on October 24, by Dr. Trout. The hernia was first repaired in the usual way. A high right rectus incision was then made. The gall bladder and common duct were found densely adherent to the duodenum. When the adhesions were released, the common duct was examined and no stones were demonstrated. The gall bladder was removed in the usual way. After this was done there was seen, just posterior to the site of the removed gall bladder, an aberrant gall bladder about 5 cm. in length and 1 cm. in width. This viscus was buried in the liver substance, only the posterior wall being visible, and with a cystic duct about 2 cm. in length connecting it with the true cystic duct. The aberrant gall bladder apparently contained no bile and had an appearance of atrophy. It was not removed but left in situ.

The postoperative course was uncomplicated. The wound healed well and the patient was discharged after three weeks in the hospital. Before discharge she was again given the gall-bladder dye but the aberrant gall bladder failed to be visualized.

The case reported seems to fall into Boyden's third class since the duct from the supernumerary gall bladder joined with the true cystic duct before it entered the common duct. This is the type most frequently found in man.

Since the appearance of Boyden's article in 1926, 14 cases of duplication of the gall bladder have been reported, including our own.

In 1927 A. Priessel[3] reported a case of two gall bladders lying side by side but having separate ducts.

Wakely[4] also reported a case in which the supernumerary gall bladder was filled with stones and was removed at operation.

Garafolo[5] reported a case of double gall bladder in 1927.

Meyer[6] reported a case of cleft gall bladder with a septum dividing the two cavities but allowing them to communicate through a small opening.

Wolfson[7] in 1929 reported a case in which the duct from the supernumerary gall bladder entered the common duct separately from the true cystic duct.

Climan[8] in 1929 reported a case with two gall bladders demonstrated by cholecystography. Both were apparently normal.

Holderman[9] in 1930 reported a case with a septum dividing the gall bladder into two parts, each of which had a separate duct.

Petrina[10] in 1930 reported a case of double gall bladder having two cystic ducts with a stone in one duct.

Hayes[11] in 1931 reported a case of double gall bladder with two cystic ducts.

Croudace[12] in 1931 found a supernumerary gall bladder lying in the liver substance above the true gall bladder and about half its size. The duct in this case could not be demonstrated.

Cove[13] in 1931 reported 2 cases of double gall bladder.

Strukow[14] in 1931 reported a case with two gall bladders.

Since 1926, then, 14 cases have been reported including our own. Six of these fall immediately into Boyden's third group. In the other cases, the course of the supernumerary cystic duct could not be determined accurately enough to allow their classification. Boyden reported 20 cases previous to 1926, which with the 14 cases here reported make a total of 24 cases found and reported to date.

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[For Remainder of References see p. 147.]

STUDIES ON THE EFFECT OF SPLENECTOMY ON GENTALIA OF WHITE MICE

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THE question as to the relation of the function of the spleen to that of other organs has been well investigated. Its effect on the blood stream is universally accepted, and its endocrine-like character is of more recent verification. The value of splenectomy has been recognized in many diseases, especially those accompanied by various forms of hypogenitalism, as seen often in Banti's disease, Laennec's cirrhosis, hemolytic icterus, and other diseases having splenomegaly, and observers claim certain body changes in the individuals thus treated. However, not enough uniform results have been found to be of value.

The problem too, of the effects of splenectomy on the genitalia has come to the minds of several workers: Heister, Bardeleben, Kocher, A. S. Schulze, Giunto, Fischer, Francisco, and most recently, Radossavlyevitch,[1] Kostitch,[1] and Télébakovitch. The findings of these men have been somewhat contradictory.

Heister, Bardeleben and Kocher[3] claim that splenectomized animals remain as potent as normal animals. However, A. S. Schulze reports contrarily, claiming that the number of young born on the average to splenectomized dogs and cats is much less than with the normal animals. Giunto reported that splenectomy causes atrophy and necrosis of the genitals, and this opinion was confirmed by Fischer. At a later date, Francisco corroborated the results of Giunto and Fischer in his work on guinea pigs. Kostitch and Telebakovitch performed carefully controlled experiments on male white mice and their results were entirely contrary to the later three. They splenectomized a group of animals before puberty (weight 6.5 to 8 gm.), and a group of older animals (13 to 14 gm.). Controls of the same litters were used, and no differences were found, the animals having been killed from one to four months postoperative. This proved that splenectomy on the young and on the older animals did not give testicular atrophy. Microscopical examinations of those animals operated upon before puberty showed no testicular atrophy, the seminal vesicles were normal and the spermatocytes were normal too. Many spermatozoa were in the seminal vesicles. Splenectomy after puberty had no effect on the genitals. These authors also reported that the weight of the animals operated upon was somewhat arrested and their body growth retarded. Animals killed four and one-half months after operation showed increased activity in formation of spermatozoa.

Kostitch, together with Radossavlyevitch, in the same month reported on the effects of splenectomy on the ovarian function. These men were inspired in this study, in that, in the humans with diseases causing splenomegaly and secondary hypogenitalism, splenectomy appears to cause a retrogression of this hypogenitalism and the organs seemingly return to a normal state. White mice were used, aged from twenty-five to thirty-five days and their vaginal secretions were checked to determine the oestrus. The controls were approximately of the same age. Twenty-five females were used. Two mice showed no oestral cycle for three months postoperative. Of twenty-two others, the

[1] Radossavlyevitch and Kostitch. Effet de la splénectomie sur la fonction ovarienne. *Soc. de Biol. de Belgrade*, p. 54, November, 1928.

[2] Kostitch and Télébakovitch. Effet de la splénectomie sur la glande génitale male. *Soc. de Biol. de Belgrade*, p. 56, November 29, 1928.

des Weibes. Wien, Urban and Schwarzenberg, 1924, 1: 660.

[3] Halban, B. J. and Seitz, L. Biologie und Pathologie

oestrus appeared from one to fourteen days earlier in sixteen animals than in the controls (as judged by vaginal secretions). The other six animals had oestrus appear from two to four days after the controls. Of the later, three were in puberty (over 10 gm.) at the time of the operation. Thus of the nineteen animals weighing less than 10 gm. at the time of operation, three showed retardation and the others showed acceleration. The conclusion drawn was that between the spleen and the female genitalia, there exists a definite hormone relationship, and that the splenic hormone acts as a check on the ovarian hormone.

We have studied several groups of splenectomized white mice from two different angles. First, as to the effect of splenectomy on the genitalia of both male and female mice before puberty, gross and microscopic studies having been made; and secondly, the actual potency of these mice when operated on before puberty.

The animals used were three and one-half to five weeks old, weighing from 5.5 to 8 gm. Ether was used as the anesthetic. For each set of animals used, controls from the same litter and of the same sex were kept.

In Problem I, the animals were killed about six weeks after operation, and their genitalia studied grossly and microscopically. The weight of the experimental animals did not vary in any regular manner from that of the controls. For example, in one group a female mouse operated on weighed more than any of the controls, while two weighed less than the average.

The fat body surrounding the testicles in the males operated on was lost, and the seminal vesicles appeared smaller. The testicles appeared to be normal in size and shape. Microscopically, there were no essential differences in either testes or seminal vesicles except that in the animals operated on spermatogenesis appeared to be better, and there were more spermatozoa present in the epididymis.

In the females operated on, the ovaries were apparently the same size as those of the controls, but the peri-uterine fat was less than in the controls. No other gross changes were observed. Microscopically, the vaginae of the mice operated on appeared to be more advanced in development. There were no essential differences in the epithelium or the musculature of the uteri. The uterine glands in the splenectomized females were empty and those in the controls full. The ovaries were functioning fully in both the operated animals and the controls, with corpora lutea present, but apparently better in the splenectomized mice.

In Problem II, the animals used were also three and one-half to five weeks old, weighing from 5.5 to 8 gm., most being of the lesser weight. One month after the splenectomies, the mice having reached well into puberty, were mated. Males operated on were mated with normal female controls, females operated on were mated with normal male controls, and then males and females, both operated on were mated. All the females bore young of normal character and strength and the number of young in the litters was of normal variation.

The only conclusion that can be deduced from the results in Problem I is that while there appears to be slightly accelerated ovarian function in the ovaries in their corpus luteum production, and in the testicles, in their spermatozoa production, that essentially the genitalia are not changed by splenectomy, nor are the animals themselves apparently changed by the operative procedure, there being no retardation of body growth.

In Problem II, the results speak entirely against any loss of potency in either the male or the female mice, and against splenectomy affecting the next generation, and too, there did not appear to be any increase in reproductive powers.

This work was done at the Erste Frauen Klinik, Vienna, Austria. Special thanks and gratitude are due Professor Dr. Oskar Frankl and Dozent Dr. Ludwig Kraul for allowing me the free use of the material at their clinic and also for their invaluable advice.

TUBERCULOSIS OF THE THYROID

CASE REPORT AND A REVIEW OF THE LITERATURE*

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TUBERCULOSIS of the thyroid gland is a chronic specific process which is rarely of clinical importance and is seldom diagnosed before operation. It is usually confused with malignancy, chronic non-specific thyroiditis, or forms of goiter. Occurring at all ages, it is usually found in the presence of goiter and without demonstrable signs of tuberculosis elsewhere in the body. It is a relatively benign lesion, very amenable to treatment, and is chiefly important because of the similarity which it may bear to malignant degeneration of the thyroid.

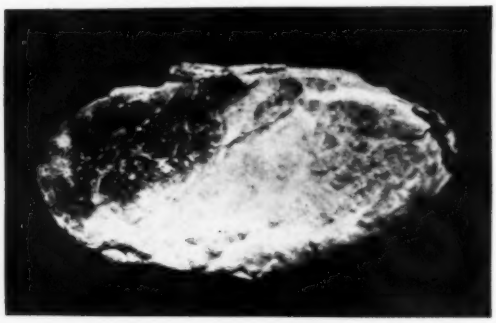

FIG. 1. Gross appearance of gland on section, white areas being tuberculous process and dark areas more normal thyroid tissue.

This disease was unknown until the latter half of the nineteenth century. In 1861, Rokitanski[45] did not hesitate to say that tuberculosis is not found in the thyroid gland. However, in the following year, Lebert[34] established the possibility of this condition by reporting a case of general miliary tuberculosis, and Cohnheim[10] in 1867, made the statement that the thyroid gland was not as immune to tuberculosis as had been previously supposed. In 1876, a second case was reported by Cornil and Ranvier[12] and in 1878 Chiari[9] reported 7 cases discovered in 100 autopsies on individuals dying of a tuberculous infection. At about the same time other reports appeared by Virchow, Quinlan, Hegar, Cohnheim and Weigert (as quoted by Aubriot[3]) of autopsies in which the thyroid gland was involved in cases of miliary tuberculosis. Other reports, first by Virchow[57,58] and later by Weigert, Grasset and Estor, Fraenkel, Hegar, Perry, and Volker[3] describe tuberculous infiltration and caseation occurring in individuals in whom tuberculosis had not been suspected during life. Dumorland[18] in 1879 reported a case in which a fistula of the neck developed as the result of a tuberculous involvement of the thyroid gland.

The clinical identification of this lesion was first made, about thirty years after its discovery, by von Bruns[60] who found at operation an isolated tuberculous lesion of the thyroid in a woman of forty-one years of age, who also had enlarged cervical nodes. An involvement of the left apex was discovered at autopsy.

Although numerous papers had appeared in the continental literature on this subject it is evident that they had not attracted general attention for in 1890, before the London Pathological Society, James Berry[5] exhibited a thyroid gland containing a miliary tubercle obtained from a patient dying of miliary tuberculosis. Berry stated that he had not been able to find a specimen of tubercle of the thyroid in any of the twelve London Museums or those of Oxford, Birmingham, Newcastle, Edinburgh, Glasgow, Geneva, Berne, or Zurich. A few months later, however, 4 cases were reported in the transactions of the same society[39,59] in which tubercles had been found in the thyroid glands of children suffering with miliary tuberculosis, and

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six years later, Sir Humphry Rolleston[46] in reporting a case before this society, said, "In generalized tuberculosis, miliary tubercles are probably far from rare in the thyroid if carefully looked for." In 1908, Albert Kocher[32] reported that of 3200 thyroids removed at operation at his clinic, but one was involved by tuberculosis.

In America tuberculosis of the thyroid was first described by Chappel[8] in 1894. He was followed in 1910 by Halstead[25] who reported a case in which the skin had been involved. In 1911, DaCosta[15] discussed it in his "Modern Surgery." In the following year, Arnd[1] of Berne reviewed the literature and described 3 cases of his own successfully treated by surgery. Forty cases discovered in material removed at operation have been reported from the Basle Pathological Institute in papers by Ruppanner,[47] Hedinger,[26] and Uemura.[55] In 1917, Mosiman[37] reported 9 cases from the Crile Clinic, reviewed the literature and discussed the experimental work done up to that time. Plummer and Broders[42] in 1920 described 7 cases from the Mayo Clinic and discussed the connection of this condition with hyperthyroidism. In 1925, Aubriot[3] reviewed the continental literature and summarized the reported cases which had been identified clinically. A very comprehensive paper appeared in 1926 by Coller and Huggins[11] in which they summarized all of the then reported cases and described 5 of their own. In the same year Higgins[27] reported 5 additional cases from the Crile Clinic. In 1928, Smith and Leech[51] reported 3 cases from the Lahey Clinic found in the course of 1500 operations and 100 autopsies. The latest American review of the subject is that of Banford Jones[31] who reported 2 cases from the Strong Memorial Hospital and discussed the relationship between tuberculosis of the thyroid and thyroid function.

Recently, several interesting reports concerning this condition have appeared in the European literature. Frederikson and Portman[21] describe a case in which, under their personal observation, the patient developed pulmonary tuberculosis, then struma on a toxic tuberculous basis, and finally miliary tuberculosis in an adenomatous nodule of the struma. Vallata[56] reports a case of cold abscess in which the signs and symptoms regressed after repeated drainage. Hofhauser[28] advises that tuberculosis of the thyroid be excluded by frozen section in all cases of thyroid grafting. Askanazy[2] writes of a case in which the presence of tuberculosis in the thyroid tissue was discovered after a graft had been made. The diseased tissue was removed after eight days with no untoward results. A recent work which has appeared on this subject is that of Dimtza,[7] in 1930, who describes a case treated successfully by massive doses of *x*-ray in the belief that it was malignant.

The incidence of tuberculosis in the thyroid gland is indicated in Table 1. In some of the series given, the cases have been reviewed with particular consideration to the possibility of tuberculous involvement. In others, only those cases were included which were discovered at the routine pathological examination.

Table 1

Author	Number Cases Examined	Percent with Tb. Lesions
At Autopsy		
Kocher, A.[32]	....	4–12
Fraenkel, E[20]	1563	10
Chiari, H.[9]	100	7
At Operation		
Kocher, A.[32]	3200	0.03
Smith, L. W., and Leech, J. V.[51]	1600	0.19
Hedinger, E.[26]	608	1.60
Higgins, C. C.[27]	9300	0.15
Coller, F. A., and Huggins, C. B.[11]	1200	0.41
Jones, T. B.[31]	67	2.00
Uemura, S.[55]	1400	1.70
Writer	590	0.17

Total number cases: 17,965.
Average incidence: 0.34 per cent.

In 107 cases discovered at operation, which were collected from the literature by the writer, 83 per cent were in females.

The individual ages varied from two to seventy-four years. The bulk of the cases were widely scattered from twenty to sixty, with an average age incidence of thirty-five. A goiter was present in 78 per cent: of these 55 per cent were nodular 27 per cent exophthalmic, 4 per cent colloid, and 13 per cent unclassified. In the 39 cases in this group which were definitely of clinical importance, predominately fibrotic lesions were present in 12, and caseation or cold abscesses in 27. The latter group included 12 of the 13 cases in which active tuberculosis was reported elsewhere in the body. In 5 of these cases there was bone, or bone and joint, involvement. In this connection it is interesting to note that in 1896, Sir Humphry Rolleston[46] wrote that in view of the tendency of carcinoma of the thyroid to metastasize to bone, it would be worthwhile to study the condition of the thyroid gland in a series of cases of tuberculous osteitis.

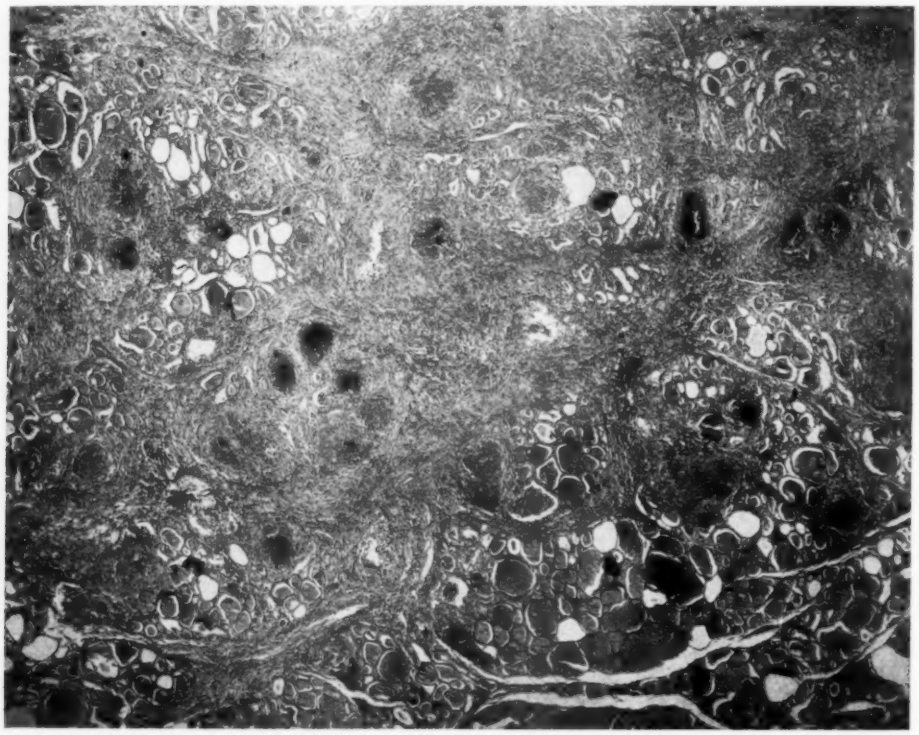

Fig. 2. Low power view (20 ×) of tissue showing tubercles and infiltrating manner of growth. Colloid-containing areas of gland are shown.

The following report is of a typical case of tuberculosis of the thyroid seen by the writer. It was the only case occurring in a series of 590 thyroidectomies. No routine search was made specifically for tuberculosis, however, and localized lesions may have been overlooked.

On July 18, 1931, E. P., white male, age forty-three, who had operated a lumberyard for fifteen years, appeared at the clinic complaining of difficulty in swallowing, dyspnea on exertion, occasional nocturnal dyspnea, nervousness, and irritability. Family history was negative for tuberculosis. The patient had been operated on at the age of twenty-six for appendicitis. There had been no other serious illnesses, nor any signs of tuberculosis. He had been seen in May, 1928, when he complained of lack of energy. At this time *x*-ray examination showed the lungs to be normal. The only positive finding was a moderate secondary anemia and a white blood cell count of 8,000. The patient was given iron and advised to take more outdoor exercise. His condition was

satisfactory until May, 1931, when he began to notice a slight difficulty on swallowing which he described as resembling a very deep sore throat. This progressed, he became nervous and irritable, and dyspnea, due to pressure on the trachea, developed. His appetite was good at this time, and he perspired readily. There was no tremor, eye signs, or fast pulse. His condition did not suggest hyperthyroidism. On physical examination the patient was found well developed and well nourished. The left lobe of the thyroid was slightly enlarged, regular in outline, and very hard. It was not attached to the surrounding tissues. A chest plate was negative. Nothing else of importance was found. Laboratory examination showed the blood Wassermann and Kahn reactions to be negative; R.B.C. 4,200,000; H. B. 68 per cent; W.B.C. 8600; and the urine to be normal.

Preoperative diagnosis: Riedel's struma, or early malignancy.

Operation: At operation under local infiltration anesthesia, the right lobe was grossly normal. The left lobe was diffusely enlarged, non-adherent to its capsule, and very firm. On complete removal it was found to be firmly connected to the trachea by scar tissue. The postoperative course was uneventful. At the present time (six months after operation) the patient is apparently well.

Pathological Report (Dr. I. Y. Olch): Gross Pathology: Gross specimen consists of a lobe of a thyroid which has been preserved in formalin. The specimen measures $5 \times 3 \times 3$ cm. It is very hard and bisection of the specimen reveals a cut surface that is made up mostly of firm, white tissue. At one end of the specimen there is a brown area about 1.5 cm. in diameter which evidently represents the remaining colloid containing thyroid tissue. The rest of the tissue is grossly suggestive of carcinoma.

Microscopic Pathology: Sections show that the areas of white tissue are made up of marked inflammatory reaction. The invading cells being mostly lymphocytes and mononuclear wandering cells. In some areas giant cells are seen and in other places there are areas of necrosis. The normal thyroid tissue has been crowded out by this inflammatory reaction and what remains of thyroid acini show no abnormal change.

Diagnosis: Tuberculosis of the thyroid.

The pathological picture of tuberculosis of the thyroid is no different from that seen in other parenchymatous tissues. In some cases caseation and liquefaction predominate, in others the chief reaction is fibrosis. Tuberculous infection of the thyroid usually occurs through the blood stream.[35] A few cases, constituting about 0.3 per cent of those reported in the literature, have been described in which the thyroid was involved by extension from surrounding muscles,[16,58] lymph nodes,[24] and long-standing sinuses which passed near the gland.[43] An important source of infection may be by direct extension from the trachea. In view of the intimate anatomical relationship between the trachea and the thyroid, and the frequency of tuberculous laryngitis in pulmonary tuberculosis[39] (as high as 32 per cent in advanced cases), this method may be of more importance than has been suspected. The following cases suggest in varying degree this mode of onset.

Budd and Williams:[7] Bronchitis with sore throat and coughing preceded the development of the thyroid lesion.

T. Banford Jones:[31] Dysphagia for three months was followed by hoarseness and enlargement of the thyroid gland.

Smith and Leech:[51] After a bad cold a tender lump appeared in the region of the thyroid which slowly subsided. At the initial examination the patient complained of hoarseness, weakness and loss of weight.

Roger and Garnier:[44] Tuberculosis of the thyroid and larynx were observed in the same individual.

Chappel:[8] A sore throat lasting five days was followed by a troublesome cough, hoarseness, and enlargement of the thyroid. Examination indicated tuberculosis of the larynx. A sinus developed over the isthmus which discharged material containing tubercle bacilli.

Askanazy:[2] Two cases of chronic tuberculosis of the thyroid gland developing following ulceration in the lower pharynx, perichondritis, and retrothyroid abscess.

Berard,[4] Fraenkel,[20] Rolleston:[46] Autopsy cases described in which the thyroid, larynx and esophagus were involved in salivary glands, which react similarly, are seldom involved by tuberculosis. In experimental work on laboratory animals

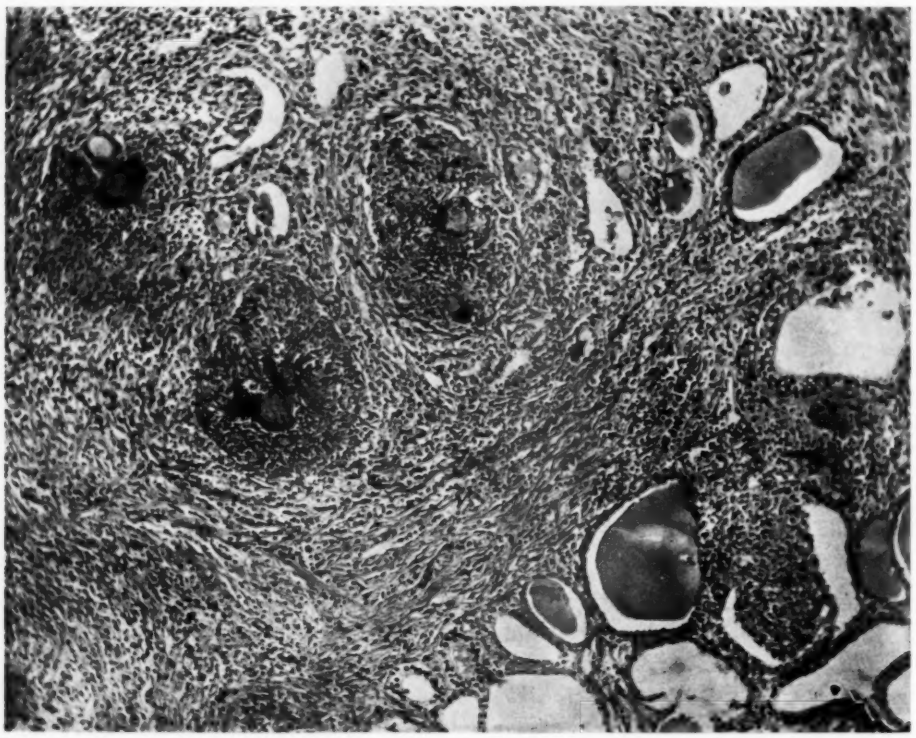

Fig. 3. Higher power (150 ×) view showing three tubercles at edge of advancing tuberculous process.

one confluent tuberculous lesion.

The explanation of the rarity of tuberculous infection of the thyroid gland and its infrequent association with active tuberculosis elsewhere in the body lies in the balance between infection and resistance in the individual case. In addition to the usual factors concerning the number and virulence of the invading organisms and the non-specific resistance of the host, various writers have discussed the responsibility of several conditions peculiar to the thyroid gland as causative factors in this process. These will be considered in the following paragraphs.

As has been noted, it has long been believed that the thyroid gland possessed an unusual resistance to the development of tuberculosis. Pinoy[41] ascribed this to the ability of the thyroid to react by fibrosis, in view of the fact that other organs such as the pancreas and the it has been shown repeatedly[44,53,54] that it is possible to produce infection by the injection of tubercle bacilli into the carotid artery. By using varying amounts of a constant emulsion of tubercle bacilli, evidence was obtained to indicate that amounts insufficient to affect the thyroid were able to produce infection in the spleen, kidneys and testicles.[49] As a result of this experimental work and of clinical studies it became evident that although the thyroid was more resistant than other organs to tuberculosis, the small number of cases in which the lesion became sufficiently extensive to attract clinical attention could not be explained on this basis.[26] The conclusion has been reached, therefore, that the thyroid gland has a strong tendency to heal spontaneously.[26,38,55]

The presence of lymphoid tissue in the thyroid gland has been suggested as a predisposing factor to the development

of tuberculosis in certain cases. Numerous writers[11,13,26,37,50] have reported its presence. Some believe that it provides a point of low resistance in which the infection may develop until it is capable of invading the surrounding thyroid tissue.[50] Others[26] are of the opinion that its presence is coincidental and describe cases in which it was present but unassociated with the tuberculous process. This question is complicated by the frequency with which lymphoid hyperplasia occurs in exophthalmic goiter;[6,32] its presence with atrophy due to iodine, adenomata and toxic influences;[61] and the great resemblance which these areas may bear to fetal rests,[19] and to areas of lymphocytic infiltration produced by the tuberculous process.[16,32] The importance of this factor is not clear at the present time.

The possibility that adenomata of the thyroid gland may aid in the establishment of a tuberculous process by providing areas of tissue compression and impaired vascularity has been widely discussed.[11] It has been noted that the majority of instances of caseous tuberculosis have occurred in connection with adenomata.[11,55]

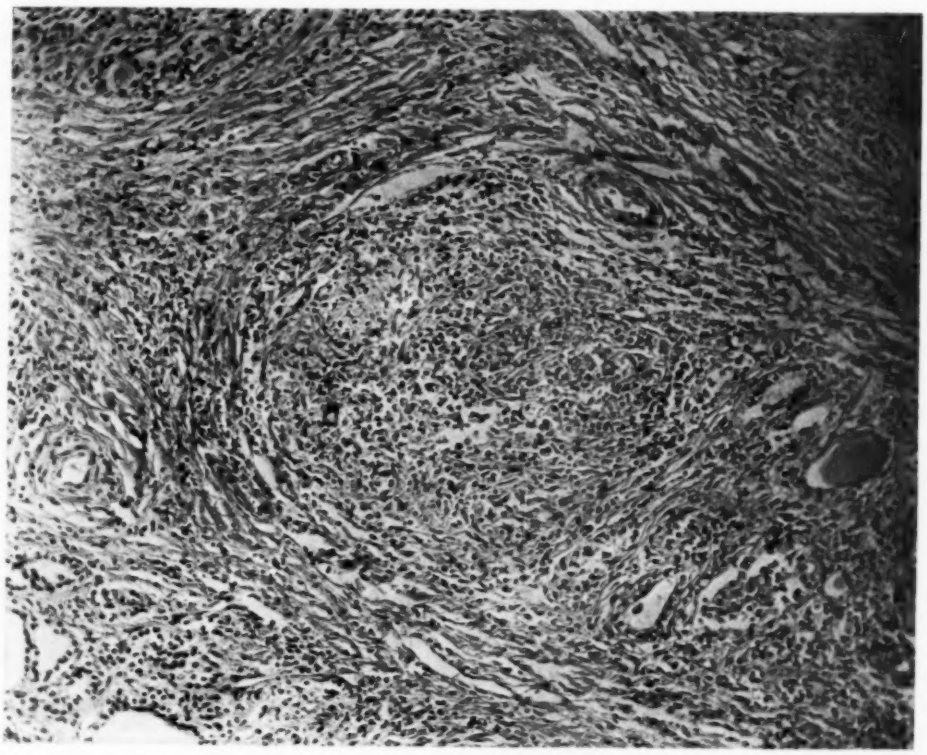

Fig. 4. (150 ×) Typical area of marked connective tissue proliferation in which a single giant cell remains.

In 107 cases of tuberculosis of the thyroid gland collected from the literature, nodular goiter was reported in 44. This group included 79 per cent of the cases showing necrosis and caseation. Inasmuch as the goiter had been present from eleven to thirty-five years in many instances, it seems probable that the goiter preceded the onset of the tuberculosis in the majority of cases.

The relationship between hyperthyroidism and tuberculosis of the thyroid is one which has received much attention. Each condition has been considered from a causative aspect in regard to the other.[26,48,55] A very thorough discussion of tuberculosis as a factor in hyperthyroidism by Uemura[55] appeared in 1917. He showed that the appearance of a typical or atypical Basedow's disease at the close of acute or chronic processes such as rheumatism, syphilis, influenza, tuberculosis or typhoid fever was

not infrequent. He quotes other papers[16,36] in which a histological picture of Basedow's disease was produced by the injection of bacterial toxins, and mixtures of paraffin and calcium chloride. He concluded that it is possible in certain cases of low grade tuberculosis of the thyroid gland to develop hyperthyroidism. No definite conclusions are reached on this subject in the literature except for a general agreement that an extensive destruction of the parenchyma results in hypothyroidism.[7,11,43]

Autopsy figures[9,20,32] indicate that from 4 to 12 per cent of individuals dying from tuberculosis show some signs of tuberculous involvement of the thyroid gland. Since from 0.076 per cent[29] to 0.1 per cent[52] of the population die of tuberculosis each year, and approximately ten times that number are sick at all times, it would seem that some degree of tuberculous involvement of the thyroid is not uncommon and its occurrence in connection with other conditions of the thyroid would be expected in a small percentage of the cases. Thus if tuberculosis of the thyroid had a marked tendency to result in hyperthyroidism, one might expect to find it fairly commonly associated with this condition. This is not the case, however, as only 21 cases have been reported in which the two conditions existed in the same individual. It is noteworthy that the incidence of exophthalmic goiter in association with tuberculosis of the thyroid gland is far greater in American than in Continental literature. In the cases studied by the writer, the combined condition occurred about ten times as frequently here as it did abroad. Since exophthalmic goiter constitutes a much larger group of the thyroid cases which come to operation in America than it does in Europe, it would seem that there is very little etiological relationship between tuberculosis and hyperthyroidism and that their presence in the same individual is usually coincidental.

Tuberculosis of the thyroid gland produces no typical clinical picture. It may occur at any age, but usually is seen between the ages of twenty and sixty years. It is chiefly found in women and in the presence of goiter. The most constant sign is a diffuse or nodular enlargement of the gland which has appeared within a few weeks or months. One or both lobes may be involved. The thyroid may be very hard if the lesion is of the fibrotic type or soft and fluctuating if liquefaction has occurred. It is frequently tender and there may be radiating pain in the distribution of the second, third and fourth cervical nerves. In early lesions the thyroid gland is freely movable but as the condition progresses it tends to become fixed to the surrounding structures. Occasionally the recurrent laryngeal nerve is involved. Pressure symptoms may arise causing difficulty in breathing and swallowing. In one case death was caused by asphyxia. With such vague findings it is not surprising that most diagnoses are made either at operation or at necropsy.

The question has repeatedly arisen of the permissibility of diagnosing tuberculosis of the thyroid merely from its microscopic picture. In many of the cases reported in the literature it was impossible to demonstrate tubercle bacilli in the tissue, and after fixation, recourse to animal inoculation was no longer possible. This subject was reviewed by Mosiman,[37] who concluded that the majority of the cases reported at that time had been diagnosed on this basis and that such a procedure was justifiable. In 9 of 10 cases studied, Hedinger[26] was able to demonstrate acid-fast organisms by the antiformin method. It has been pointed out, however, that syphilis may produce a picture indistinguishable from tuberculosis in the thyroid. Recently, Jaffe[30] has described 4 cases of mild hyperthyroidism in which tubercle-like lesions were found without necrosis. Careful search with the antiformin method revealed no tubercle bacilli. He ascribes the condition to a non-infectious involution of newly formed and old follicles. In a case described by

Curtis,[14] in which tubercles were later found on section, an emulsion of the fresh tissue was injected into a guinea-pig with no results. Tuberculoid structures are frequently encountered in routine examination of thyroid tissue. However, if associated with a definite inflammatory reaction in the surrounding tissue it seems unlikely that such lesions are due to an involution process. In view of the attenuating effect of thyroid extract on tubercle bacilli[54] and the infrequency of tubercle bacilli in fibrotic lesions[46] of the thyroid, guinea-pig inoculation cannot be considered infallible in ruling out tuberculosis. It is probable that in lesions of clinical importance, after lues has been excluded, a diagnosis of tuberculosis can be made from the microscopic picture with a high degree of accuracy.[3,32]

The prognosis in tuberculosis of the thyroid following surgical treatment is usually good. If a large amount of the thyroid tissue is destroyed or removed, myxedema may result. In untreated cases sinuses occasionally form which may penetrate to the skin, the trachea, the esophagus, or to the mediastinum.

The majority of these cases have been treated by surgery. Unless a positive diagnosis can be made by aspiration in the presence of a cold abscess, this is the safest procedure in order that malignancies are not overlooked. In a few cases, successful *x*-ray treatment has been reported.[17,22,33] General hygienic measures are important as in the case of tuberculosis in other organs. After a diagnosis has been made of this disease, the patient should be re-examined for active lesions elsewhere in the body.

CONCLUSIONS

1. Tuberculous lesions of the thyroid have been reported in from 4 to 12 per cent of individuals dying of active tuberculosis and in an average of 0.34 per cent of thyroid glands removed at operation for all causes.

2. In 107 cases in the literature studied by the writer, active tuberculosis elsewhere in the body was reported in only 14 cases.

3. Among the factors which may be concerned in the development of this condition are pre-existing goiter, the presence of lymphoid tissue within the thyroid gland, hyperthyroidism, and a normally high tissue resistance to tuberculosis.

4. Clinically, the types of lesion seen vary between two extremes: (1) a necrotic type with caseation or liquefaction, and (2) a fibrotic type associated with giant cells and lymphoid cells.

5. The preoperative diagnosis is only possible by aspiration of a cold abscess or with material obtained from a draining sinus.

6. Not infrequently there are lesions in the thyroid which may be confused with tuberculosis.

7. A typical case with clinical course is reported.

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CHORDOMA OF THE THIRD LUMBAR VERTEBRA

REPORT OF A CASE*

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CLEVELAND, O.

TUMORS of notochordal origin known as chordoma are most frequently found in the region of the spino-occipital synchondrosis and sacrococcygeal region. Few have been reported involving the vertebral bodies. In 1930 Machulko-Horbatzewitsch and Rochlin[1] found that in only 8 of the 103 cases of chordoma reported up to that time was one or more of the vertebral bodies involved.

The peculiar distribution of these tumors has been explained upon an embryological basis. Those involving the vertebra are said to arise from remnants of the notochord which persist as the nucleus pulposus in the intervertebral discs, or from notochordal cells which may be scattered through the vertebral bodies.[2]

Pain is one of the early symptoms and in the later stages is accompanied by signs of cord compression. Roentgenograms show bony changes, but the roentgenological changes vary, and are not characteristic.

Chordomas rarely metastasize but infiltrate locally. They are resistant to radium and roentgen-ray therapy. Because of their location, complete surgical removal is usually impossible.

CASE REPORT

A white woman, sixty-two years of age, was referred to Lakeside Hospital, November 11, 1929, complaining of pain in the lower back and both legs of fourteen months' duration. Following a long automobile trip in August, 1928, she began to have pain in the lower part of the spine and particularly in the lateral and posterior aspects of the left thigh. The pain had been almost constant and had slowly increased in severity. A ventral hernia was repaired several months after the onset, but failed to relieve the pain. In July, 1929 she first noticed weakness in both legs, and almost simultaneously pain appeared in the right thigh. Shortly afterward the legs became numb below the kness, and the patient could not walk. Control of the anal and urethral sphincters was lost. She was admitted to Lakeside Hospital and a diagnosis of spinal cord tumor was made, after lumbar puncture below the third lumbar segment had revealed yellow fluid and no increase in flow with jugular compression.

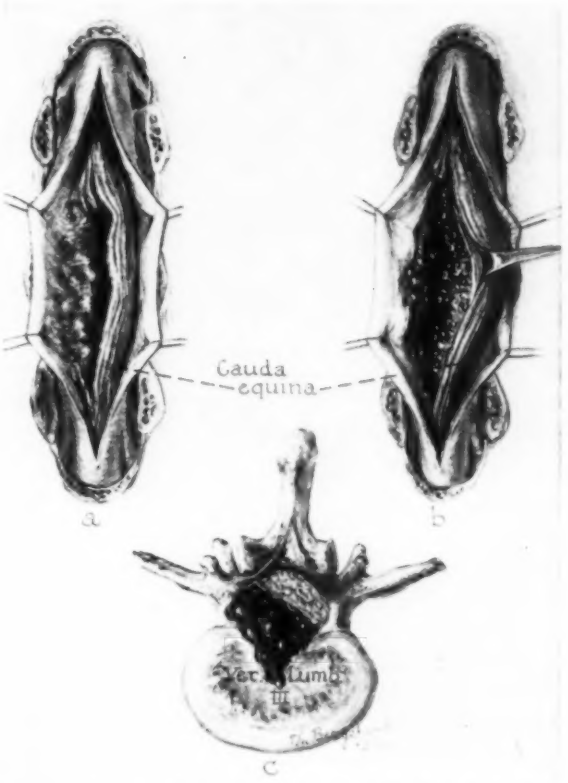

FIG. 1. Nerves of cauda equina are displaced to right by tumor. B. Ventral dura has been opened and a portion of tumor removed. C. Estimated extent of tumor in body of third lumbar vertebra.

[1] Machulko-Horbatzewitsch, G. S., and Rochlin, L. L. Klinik Pathomorphologie und Histogenese der Chordome. *Arch. f. Psychiat.*, 89: 222–262, 1930.

[2] Cappell, D. F. Chordoma of vertebral column with three new cases. *J. Path. & Bact.*, 31: 797–814, 1928.

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Physical examination showed an alert, fairly well-preserved old lady in good general condition. Positive findings were confined to the lower extremities. Both legs below the hips were paralyzed and flaccid, and the reflexes were abolished. All sensations to cold and touch, and the vibratory sense were lost below the knees in front and up to the buttocks posteriorly. There was complete loss of sphincter control. Roentgenograms showed irregularity of outline of the third lumbar vertebra. The left side of the vertebral body was narrowed and appeared dense, suggesting an old compression fracture.

Laboratory Findings: Slight trace of albumin in the urine; Wassermann reactions of the blood and spinal fluid were negative; the blood studies were normal.

Operation: On November 14, 1929, laminectomy was performed by Dr. E. C. Cutler, and the spinous processes of the second, third and fourth lumbar vertebrae were removed. The dura was distended and was opened from below the first lumbar vertebra to the sacrum. The cauda was found to be dislocated posteriorly and to the right by a ventral tumor mass which reached from the first lumbar to the sacrum and which had grown through the dura into the canal (Fig. 1A). Two of the filaments of the cauda equina were surrounded by tumor. The ventral dura was opened by dislocating the cauda to the right, and about 5 gm. of tumor tissue were removed (Fig. 1B). The tumor was apparently growing from within the bone (Fig. 1C).

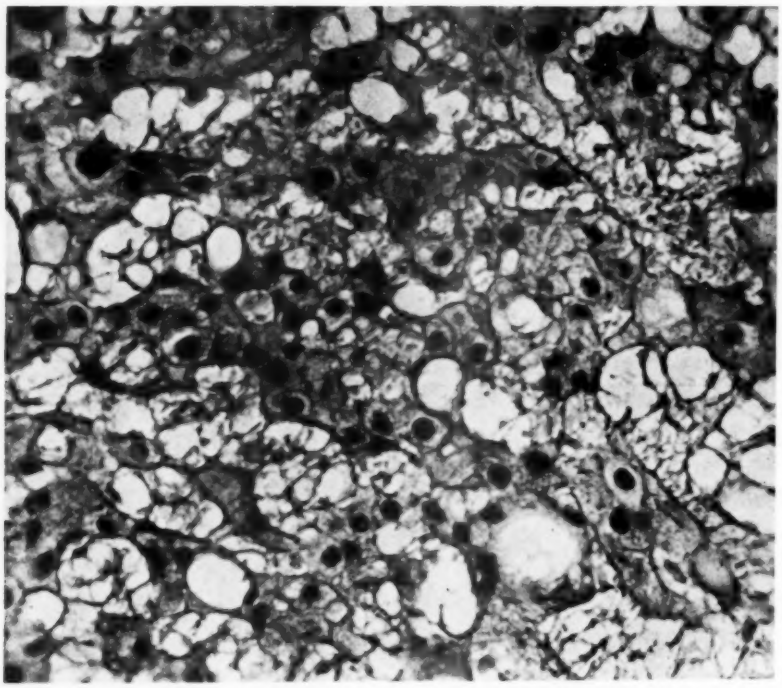

FIG. 2. Photomicrograph showing cords of large, vesicular cells. Note mucin-containing vacuoles. (× 240.)

Pathological Report: Grossly the tumor tissue was translucent and rather elastic; it had a lobulated appearance and no capsule. Microscopically, it was comprised of cords of distinctly outlined, vesicular cells of round or polyhedral shape (Fig. 2). The nuclei were relatively large, round and hyperchromatic, and mitosis was not frequent. The interstices between cell columns were filled with large mucin-containing vacuoles. The tumor was more cellular at the periphery of the lobules. The lobulation was similar to that seen in a chondroma and was produced by incomplete subdivision of tumor tissue by fibrous trabeculae. There was no evidence of encapsulation. The tissue was poorly vascularized and there were large areas of degeneration. There was invasion of bone marrow with absorption of cortex and trabeculae.

Diagnosis: Chordoma of vertebra with invasion of dura.

Postoperative Course: Within a week after the operation the patient was able to move the right leg quite freely and to flex the left leg

at the knee, but she continued to complain of severe pain in the legs. Her convalescence was prolonged by urinary infection as well as a decubitus ulcer over the sacrum. Roentgenograms ten weeks after the operation showed very little change. By the eighty-third post operative day she had regained sensation to touch, pain and temperature in the left leg and also in the right lower extremity except in the right foot which showed diminution in sensation. Motor power had returned to the hamstring muscle group on the right and to the abductors of the thigh on the left. Reflexes were still absent in both lower legs. The urethral and anal spincters had almost entirely regained their tone. However, she continued to have considerable pain in both legs.

For several months following the operation her condition remained relatively unchanged. She died November 12, 1930, one year after operation and twenty-six months after the beginning of the symptoms. Her death followed several months of progressive decline. An autopsy was not performed.

SUMMARY

A case of chordoma involving the third lumbar vertebra is reported because of its unusual location and clinical manifestations.

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* Continued from p. 119.

SOLITARY CYST OF THE KIDNEY

EXCISION OF CYST WITH SUTURE OF KIDNEY*

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UNDER the caption of "solitary cysts" there are reported practically all types of cysts of the kidney except the retention cysts sometimes found with chronic nephritis, congenital polycystic kidneys and cystic degeneration of obvious neoplasms.

There is confusion in the attempts at classification, but solitary cysts of the kidney are usually primarily grouped as hemorrhagic and serous. The former have thick walls of fibrous tissue, with perhaps some renal parenchyma or neoplastic tissue; they contain a bloody fluid with layers of more or less organized clot lining the cyst wall. Nephrectomy is almost universally demanded. On the other hand, the serous cysts have thin, delicate walls, with at times a little compressed parenchyma here and there, and are filled with clear fluid. These may be truly "solitary" or they may prove (in about 12 per cent) to be a collection of cysts. Excision of the serous cysts with preservation of the kidney is the operation of choice, and should be done when this treatment is surgically feasible. Yet it is amazing how frequently nephrectomy has seemed to be advisable in the instances reported in the literature.

Opinions concerning the origin of renal cysts vary. The arguments for and against the congenital and acquired theories are briefly presented by Hepler.[1]

If cysts be always of congenital formation, it does seem odd that symptoms are rarely produced in patients under forty years of age, but that these patients come under observation rather at the time of life when degenerative and vascular changes may be expected. Moreover such changes and congenital abnormalities are not infrequently encountered as associated lesions in kidneys bearing solitary cysts. Hepler believes that while the etiology varies, the mechanism of production is essentially the same in all cases. This depends on "a combination of group tubular obstruction and anemic degeneration of the parenchyma from circulatory disturbances, in the same segment of the kidney."

Large cysts of the kidney are rarely bilateral. They are never connected with the renal pelvis. They are usually found at one pole of the kidney, but may be located in the middle of the organ.

The case here reported sought advice for symptoms which were apparently due to an associated condition: calculus. An additional diagnosis of probable tumor was made from the pyelogram. At operation there was found a group of serous cysts which were situated in the middle of the kidney and which were easily enucleated in two masses. As the kidney was not removed, its histology is unknown.

CASE REPORT

Male, age fifty-one, a clerk, native of the United States, was admitted to Bellevue Hospital on June 2, 1930, with the history of pain in the right loin, radiating around the abdomen and down the thigh. It had been more or less constant for three months, with two moderately severe exacerbations associated with hematuria and some urinary frequency and dysuria. There was nothing significant in the family or past history.

Examination: The routine physical examination was negative except for the presence of an indistinctly palpated mass in the right kidney region, and lumbar tenderness. The urine was

[1] *Surg. Gynec. Obst.*, 668–687, 1930.

* Presented before the Section of Genito-Urinary Surgery, N. Y. Academy of Medicine, Nov. 18, 1931.

turbid and contained some albumin and a small amount of pus. The leucocyte count was 8200; differential count, normal; hemoglobin

Fig. 1. Calculus shadow in right renal pelvis.

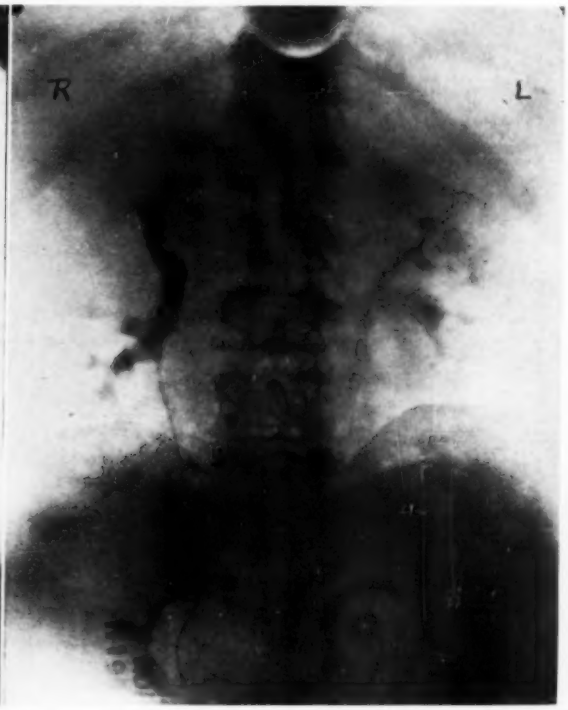

Fig. 2. Normal left renal pelvis, abnormal right pelvis (preoperative) due to solitary cyst.

75 per cent. The N.P.N. and creatinin of the blood were always within normal limits on numerous tests made both before and after operation. The Wassermann test was negative. The phthalein output was 50 and 30 per cent for the first and second hours.

Cystoscopy (June 4) disclosed normal bladder mucosa and ureteral orifices. The latter were both easily catheterized. Urines thus obtained showed no pus from either kidney, and the same percentage of urea (1 per cent). The right ureteral catheter worked badly; indigocarmine appeared from the right catheter in ten minutes and from the left in three and one half minutes, both ultimately became moderately deep in color.

Radiographs showed a shadow (Fig. 1) on the right side which the pyelogram proved to be in the renal pelvis. The pyelogram (Fig. 2) on the right side also indicated the presence of a tumor mass in the middle of the kidney, widely separating the upper and lower groups of calyces without producing much compression. A partial left pyelogram indicated normal conditions on that side.

Operation (June 12) was done under spinal anesthesia for which 2 c.c. of ½ per cent nupercaine was used. The approach to the kidney was through an oblique extraperitoneal incision, carried between the twelfth rib and the twelfth dorsal nerve. The kidney was easily exposed and brought out of the wound. In the middle of the mass was a multilocular cyst, the size of a man's fist. At either end of this was an overlying cap of renal tissue, each representing about one-half of a kidney. A small incision was made in the pelvis, a stone of 1 cm. in diameter was removed, and a bougie was passed down the ureter to the bladder without meeting any obstruction. No suture was taken in the pelvis. On opening the pelvis, the cystic mass did not change in form or size, indicating that probably there was no connection with the pelvis.

A superficial incision was made in the kidney capsule, close to and around the group of cysts. Thence by blunt dissection the cystic mass was eneucleated with unexpected ease. First a mass posterior to the midline of the convex border was removed without tying off any vessels; it consisted chiefly of two larger cysts, each about 5 cm. in diameter. Then an anterior mass

composed of several smaller cysts was dissected away. This had a deep fibrous connection which was tied before it was cut across. A thin

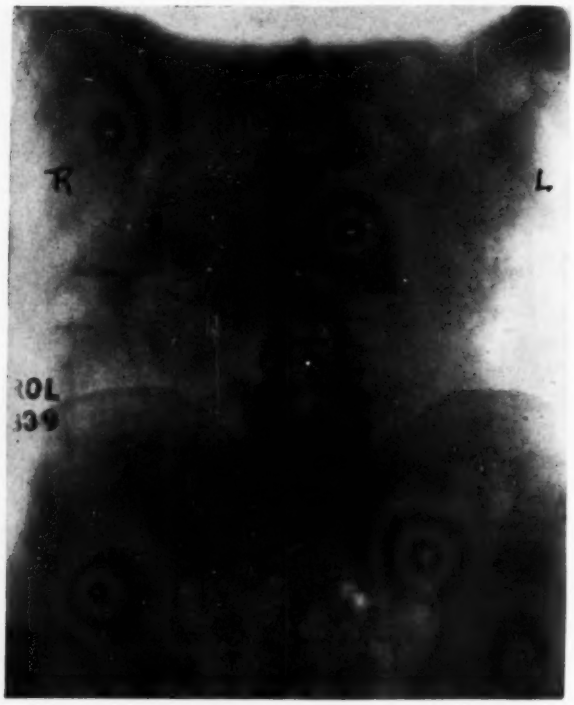

Fig. 3. Postoperative right pyelogram following excision of cyst and suture of kidney.

and superficial strip of kidney tissue between these masses was cut away. There remained a long, longitudinal rent in the kidney, with a radial one on the posterior side, the two roughly forming a "T." There was practically no bleeding. One deep mattress suture was placed posteriorly, joining the upper and lower portions of the kidney, and two similar ones joined the anterior and posterior halves, thus eliminating the deep space. About six superficial mattress sutures placed in the capsule brought the edges together neatly. The kidney was dropped back into the wound and easily assumed a high position near the diaphragm. Cigarette drains were used, and the muscles sutured in two layers with chromic catgut.

Postoperative Course: The foot of the patient's bed was kept elevated for some days, to encourage the fixation of the kidney in a high position. The temperature was not over 101°F. the first five days, but after that gradually climbed, reaching 103.6°F. by the ninth day, although the patient did not seem especially ill. Tenderness over the wound was noticed and later a deep mass was palpated. Thirteen days after operation (June 25) the wound was opened under spinal anesthesia, and an abscess of thin pus, anterior to the kidney was drained. The temperature quickly dropped after this procedure and the subsequent course was uneventful. Because of continued drainage of urine from the wound a catheter was placed in the right ureter on July 18 and allowed to remain twenty-four hours. After this no more urine came from the wound.

On August 6, urine obtained from the right kidney by ureteral catheterization showed a small amount of pus and urea 0.3 per cent, while synchronously collected urine from the left kidney contained no pus and 0.7 per cent urea; phthalein given intravenously appeared from the right catheter in ten minutes and 3 per cent was obtained in the succeeding ten minutes, while the color appeared from the left catheter in three minutes, and 10 per cent was obtained in ten minutes.

The patient has remained well to date, with no pain and no urinary symptoms. Ureteral catheterizations done in November, 1930 and November, 1931, gave virtually the same results: no pus from either kidney, and urea percentage from the right kidney about half of that from the left. The phthalein tests were unsatisfactory on both occasions because of failure of the catheters to work well; we can only state that there was faint color from the right side, while deep color came from the left.

Pyelograms of the right kidney taken in November, 1930 and November, 1931, are practically duplicates, hence the later one only is offered, showing (Fig. 3) overlapping of the upper and lower groups of calyces as seen in the anteroposterior *x*-ray exposure.

Attention should be called to the observations that the two kidneys functioned apparently equally well before the operation while the operated side was consistently behind its mate afterward. This decrease in function of the right kidney I think is explained chiefly by the use of the deep constricting mattress sutures, although the opinion has been expressed by others that such sutures do not appreciably influence the later function of the kidney. I feel that it is good practice to depend largely on superficially placed sutures in plastic kidney surgery, and to employ the deep sutures only to obliterate space and control serious hemorrhage.

DIVERTICULOSIS AND DIVERTICULITIS*

CHANNING W. BARRETT, M.D.

CHICAGO

THE subject of intestinal diverticula is not new to observers in medicine, yet it is not old as the history of diseases goes. There are numbers of carefully recorded observations, but I think the claim might be made with truth that the disease known as diverticulosis has not been taken into account by medical men at large, as has many other conditions of perhaps not greater importance.

We speak of diverticula of the bowel, as for instance, Meckel's diverticulum, but this is a congenital formation and is not taken into account by the term "diverticulosis." In the latter we mean a condition in which there are numerous acquired pockets or herniations of the mucous membrane and submucosa through the musculature. In this condition we might have few or no symptoms, and the condition found only with the *x*-ray. Again, we have diverticulitis, which is diverticulosis plus activity of infection with a resulting inflammatory reaction. This causes a greater variety of more severe symptoms and has therefore received a share of medical attention, and has been recognized, preoperatively, operatively, in the pathological laboratory and at the post mortem table. This term has been used to cover the whole condition, but more recently the term "peridiverticulitis" has been suggested by Wilson to signify that definite reaction that takes place immediately surrounding the diverticula. This is a much more limited process than frequently takes place in more marked cases, and so in these latter cases we might well speak of "paradiverticulitis," although I have not seen this term used. Then as the infection extends we may have colitis and sigmoiditis, pericolitis and perisigmoiditis, paracolitis and parasigmoiditis, local peritonitis and general peritonitis, abscess formation, adhesions to viscera, fistulous openings, etc., which all mark the different reactions of, first, injurious irritations within the bowel, and then bacterial invasion into the bowel wall, then through the bowel into the surrounding tissue or peritoneal cavity.

Telling takes the position that diverticulosis is of no more pathologic significance than the presence of an appendix, but the majority of observers are of the opinion that diverticulosis is in itself a pathologic process and one which furnishes the conditions leading to bacterial invasions with afore-named inflammatory reactions.

Practically all observers are agreed that these herniations of the mucous membrane through the musculature are acquired processes, but it is not unlikely there are instances in which a congenital weakness of the muscle and looseness of muscle bundles favor the development of this herniation.

They have been found in young and old, but the time from middle life and beyond includes most of the cases. First diverticulosis is probably a slow-developing process, and diverticulitis may be a long time forming even then. The tissue changes of middle life and beyond also lend themselves to such a process.

About two-thirds to three-fourths of the cases are found in males, and this is not easy to understand, for it would seem that the conditions which are supposed to favor its development are more prevalent in women, but evidently some point is overlooked.

Obesity undoubtedly plays a part. An over-large abdomen is the rule, with only

* Read at the 44th annual meeting of the American Association of Obstetricians, Gynecologists and Abdominal Surgeons, White Sulphur Springs, W. Va., Sept. 14–16, 1931.

a small percentage of exceptions. These over-large abdomens not only represent accumulated fat, but distention of bowels with a greatly increased bowel content of feces and gas. A fatty degeneration of musculature with lack of elasticity and contractility is found. A close study of the specimens of bowels from the postmortem rooms of the County Hospital show bowels whose walls have lost their agility; they are irregularly thickened and thinned, the inner aspect shows a surface which has become trabeculous like an old bladder with long-continued cystitis. Two features seem especially noticeable; one is numerous and rather excessive mucous membrane folds forming ridges, clefts and sometimes deep pockets or fissures of considerable length; the other is the marked hyperplasia of muscle bundle and connective tissue which in many instances seem to be forming a pocket, not so much by the mucous membrane being pushed outward, but by these ridges being pushed inward.

One of my specimens is pitted with a great number of acquired diverticula and presents a typical diverticulosis. Numerous characteristic diverticula start from the bottom of long deep pockets or cone-shaped pockets. Those which start from a more or less flat surface are very frequently surrounded by a circular or elliptical whitish ridge which gives a raised appearance and which sometimes so closes the mouth that the diverticulum is only discovered upon separation of the approximated ridges. There are numerous identical or similar areas where one might expect to find diverticula, but where no diverticula are found. Areas are seen also where a large thinned area bulges, but where no contraction exists to form anything like a mouth. The mucous folds are seen to be greatly in excess in the portion of the bowel in which the peridiverticulitis and paradiverticulitis have become so marked as to cause great thickening of the wall, not only increasing its bulk but greatly narrowing its lumen. We believe these specimens show that diverticulosis is not merely a mechanical result of over-distention pushing mucous membrane through the musculature, but that time, age, irritations, infections, putrefactions, etc. cause changes in the bowel wall, such as trabeculization, irregularities, folds, fissures, cones, mucous membrane proliferation, degenerations which make it easy for the proliferating mucous membrane to find weak places aided by increased pressure from within, due to increased contents and straining. Mucous membrane once projecting outside the bowel is subject to muscular trauma, irritations of hard contents, enteroliths and foreign bodies, making them breeding places for bacteria. Here we have the foundations for a reaction called diverticulitis and peridiverticulitis. The wall, consisting of mucosa, submucosa, and serosa, and at and near the base perhaps musculature, where the hernia is breaking through, may become reinforced by the round celled infiltration of the peridiverticulitis, or it may become weakened by distention and erosion. Infections may invade the wall and paradiverticulitis take place. Infections may approach the bowel surface and adhesive reactions of the peritoneum take place, limiting the progress of the bacteria. The bacteria may pass through the wall or gain access to the peritoneal cavity by rupture of wall and a localized abscess form or general peritoneal infection take place; occasionally this abscess ruptures into the bladder or other hollow viscus, or sometimes the rupture from the adherent bowel wall takes place into a hollow viscus without an intervening abscess. In our specimens there are enough of the diverticula opening into appendices epiploicae to give credence to the opinion held by many that this is a weak point by reason of a vessel passing through the musculature here, but enough are seen located at other places to demonstrate that the locus minoris resistentiae may be almost any place in the bowel wall. Some have suggested the operative removal of diverticula in the appendices epiploicae, but a study of a well-marked specimen

demonstrates the non-feasibility of this. Carcinoma may become engrafted upon a diverticulosis and its complicating reactions.

SYMPTOMOLOGY AND DIAGNOSIS

To one sensitized to the importance of the subject, an obese person at or past middle life should offer suspicion of colon and sigmoid trouble when constipation, diarrhea, gas formation, overfed feeling, with an irritating moisture about the anus causing itching, are present, before the late symptoms of peridiverticulitis develop. An *x*-ray picture after an opaque enema will usually discover projecting diverticular shadows at the side of the bowel shadow. The number and extent of the pockets in the diverticulosis is shown best a few days after the opaque enema when all of the barium except that in the diverticula will have passed, leaving these round or oval shadows standing out unmistakably and strikingly. Many times a white ring with a dark center is seen, indicating that the diverticulum contains a fecal mass with room enough around it for the presence of some of the opaque material. Other opaque shapes are seen, such as crescents running up to the sides indicating that the fundus is occupied by a stercolith.

If the patient is taken with pain in the left side and a mass is felt in the left inguinal region, fever and leucocytosis are present, diverticulitis or peridiverticulitis is strongly suspected. If these are accompanied by marked constipation, griping pains, inability to get results with enemas, paradiverticulitis with thickening of bowel and narrowing of its lumen are to be suspected, and an *x*-ray study should be made to confirm or deny this. If severe pain, great tenderness, chill, are superimposed upon the foregoing, a rupture should be thought of, and, whether or not an operation is chosen, great caution must be exercised. An *x*-ray must be used with great care. Gas and feces coming from the urethra will indicate rupture into the bladder. Consistent repeated hemorrhages speak in favor of carcinoma. A very short period of symptoms or a very long period contraindicates carcinoma.

TREATMENT

It is apparent that the most important treatment is prophylactic. Careless habits of eating and laxness in daily exercise lead to fat accumulations and intestinal fermentations and putrefactions which disturb bowel function and degenerate the bowel structure. No person should allow himself to become so ultra-sedentary and no person leading a sedentary life should allow himself to eat large quantities of food. A person who has had an active athletic life pays a heavy price if physical activities are neglected. Constipation and gas formations should be avoided. Obesity, constipation and an over full-abdomen should be corrected by more exercise, less food, mineral oil enemas, etc. favoring elimination of residual bowel contents. Bowel lavage leaves the lower bowel empty with bacteria and irritating materials lessened. Yeast and acidophilus-carrying products are helpful. The dihydronol as outlined by Leonard[1] promises well according to their experiments;—a clinical test has proved satisfactory and the product promises well for freeing the intestinal tract from harmful bacteria. Improvement of the intestinal conditions before diverticulosis takes place is not difficult, yet such changes may have taken place that a complete return to normal of the bowel wall may not be expected.

When diverticulosis has once developed, severe symptoms may be absent but a condition is established which tends to complications of diverticulitis, peridiverticulitis and paradiverticulitis, with marked changes in the bowel wall favoring encroachments upon the bowel lumen, perforations, with resulting complications of the peritoneal cavity, etc. In spite of this the foregoing outline of treatment may result in marked improvement.

[1] *Johns Hopkins Hosp. Bull.*, Jan. 1931.

Colon lavage and mild massage is indicated in chronic cases to facilitate the emptying of the diverticula of stercoliths and foreign substance. Great retardation may result, but an anatomical cure may not be expected.

In cases with more acute processes and in which some ileus is manifest, rest, enemas, etc. may result in emptying of the bowel with subsidence of acute symptoms. In cases of marked peridiverticulitis and paradiverticulitis with not only spastic ileus but also organic stricture, an operative procedure may be required. If the patient is infected with toxins and greatly reduced in health, a colostomy should be performed as a preliminary life-saving procedure. Some of our patients have made such improvement with a cecostomy and appendicostomy that normal function of the bowels was resumed and the cecostomy opening spontaneously closed.

After the immediate subsidence of danger, if obstruction still persists, resection may be called for, but seldom should this be done while the patient is in bad condition, as an immediate danger may be met quite as effectively by cecostomy alone. A condition requiring removal of the mass will seldom be found in good enough condition for a complete removal of the affected portion with end-to-end, or side-to-side, anastomosis. The area sometimes involves 18 inches to 2 feet of bowel and the mesocolon and mesosigmoid may be infected, thickened and friable, making a complete removal dangerous. The affected portion may be drawn outside as a time-saving and life-saving procedure, and the bowel taken off afterward and the lumen established according to method of Mikulicz. Sometimes a cecostomy is advisable at the same time but in less urgent cases, or when patients are not in good condition, a two-step operation is usually preferable. A colostomy should usually if not always precede a removal of malignant obstruction. In cases of rupture with abscess formation or localized infection, drainage and cecostomy may be called for at the same time, drainage to let out the infection and cecostomy to divert the fecal stream from the involved area. Usually in cases of rupture into the bladder a cecostomy should precede an effort at separation and repair of the viscus involved.

At present patients not calling for immediate operation are treated conservatively or not at all. Patients in so bad a condition as to call for surgical relief have a high mortality following radical operation. One can conceive of a condition calling for surgical intervention with the patient in good enough condition to render a radical operation safe, and it seems quite probable that as the condition becomes better known, with a full knowledge of its end-results becoming established, the condition will follow the history of appendicitis, cholecystitis, prostatic enlargement, and goiter, and operation elected at a time when operation would be comparatively safe.

SUMMARY

1. Constipation, putrefactions, infections, irritations produce bowel changes that make it subject to diverticulosis.

2. Keeping the intestinal tract fit may avoid changes in the bowel wall which favor the development of diverticulosis.

3. Diverticulosis furnishes pockets which become filled with fecal masses, stercoliths, foreign substances and bacteria, which result in reactions known as diverticulitis and peridiverticulitis.

4. Bacteria invade the bowel wall at such distances as to make "paradiverticulitis" an appropriate term for the resulting reaction.

5. The reactions in the bowel wall result in spastic and organic obstruction or stenosis.

6. The passing of bacteria through the thinned diverticula or thickened infected bowel wall, or through rupture, leads to peritoneal and mesenteric infection.

7. Infections from this bowel source are not infrequently causes of arthritis.

8. When diverticulosis has once developed, great care should be exercised to avoid excess of food. Irritating foods: foods containing small sharp seeds, should be avoided.

9. The bowel should be kept empty and harmful bacteria reduced to a minimum.

10. Enemas and careful manipulations should be used to free the diverticula of stercoliths, foreign bodies and bacteria.

11. Uncomplicated diverticulosis is not incompatible with comfort and good health.

12. Diverticulosis favors the development of intestinal and diverticular flora which invade the bowel wall and may pass through, resulting in peritoneal and other infections, or may be picked up by the blood or lymph streams and which may frequently be the source of arthritis.

13. Diverticulosis and moderate forms of diverticulitis and peridiverticulitis, and even paradiverticulitis may be treated by non-surgical methods.

14. Surgery may be required to combat complicated conditions.

15. We may reasonably expect to see surgery grow in favor for the less severely complicated cases as our understanding increases, yet at present caution and conservatism are the watchwords, we must always ask ourselves: will this patient stand the operation?

I wish to express appreciation of the kindness of Dr. Arthur Hanson for his painstaking *x*-ray work, and to Dr. Rosenthal of the County Hospital for the use of his post-mortem specimens.

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* Continued from p. 125.

CELLULOID CORRECTION LEGGINGS FOR BOWLEGS OR KNOCK-KNEES

EARL D. MCBRIDE, M.D., F.A.C.S.

OKLAHOMA CITY, OKLA.

THE purpose of this appliance is for treating bowleg or knock-knee deformity previous to the walking stage, for application at night, or where it is impractical to employ walking braces or surgery.

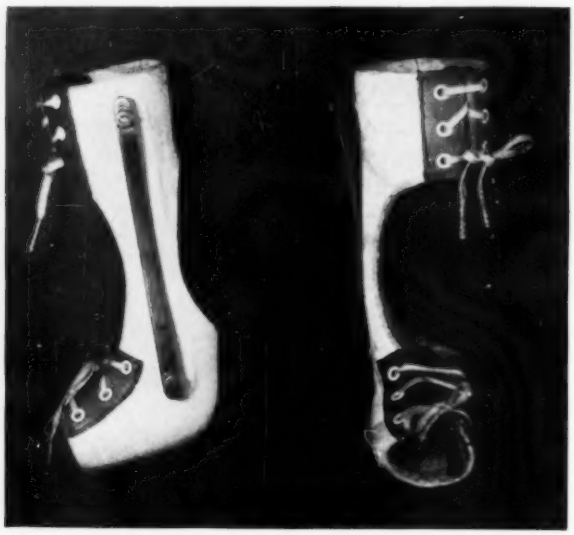

FIG. 1.

An accurately made plaster model of the leg is smoothly covered by ¼ inch white felt glued to its surface. Ten layers of celluloid and crinoline are then applied. A thin strip of steel, ½ inch wide, the length of the distance from the ankle to the knee, with a No. 8-32 stove bolt, one inch long, riveted in each end, is embedded in the celluloid layers. For bowlegs, this strip is placed on the outer side, and for knock-knees on the inner side. The body of the celluloid form is trimmed away, leaving only a 2 inch strip involving the metal piece, a complete shoe for the foot and a 2 inch band for the knee. The shoe and knee bands are fitted with laces. Another slightly curved strip of spring steel, ½ inch wide and as long as the embedded metal piece is placed with its convex surface on the embedded metal strip, a hole in each end fitting over the stove bolts. Correction is made by screwing down the nuts on each stove bolt, thus springing the form and its contents into a straight line.

FIG. 2.

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EDITORIALS

ANESTHESIA

BEGINNING with the special Spinal Anesthesia number (December, 1928) we have devoted many columns to the subject of anesthesia in its many subdivisions. Therefore, it was with unusual interest we read Frank Bortone's survey which is published in this number of the Journal.

To every surgeon this survey of anesthesias administered in the hospitals of the state of New Jersey will prove instructive and bring up many questions that constantly occupy the back of one's mind. Unfortunately, the survey in question is not conclusive. What conclusions may be drawn are open to honest criticism. The question of physician or nurse anesthetist is one made to order for endless debate. Probably in the long run and throughout the country the suggestion that a physician be in complete charge of the department of anesthesia of a hospital, even though trained nurses are capable of carrying out the actual work of giving the anesthesia, is a sane one. We say this although in a hospital in which we do the major part of our work the department of anesthesia is in charge of a trained nurse who has conducted a school of anesthesia for several years. This woman has three trained nurse anesthetists under her and, in turn, student anesthetists are trained by this group. For the past fifteen years the department of anesthesia in this hospital has been of unrivalled excellence. But

this may be the exception to the rule. It will be by more comprehensive reviews of the type we herewith publish that the correct answer will be arrived at.

As a starter, as a piece of work that should serve as a model for others throughout the country, Doctor Bortone has done a creditable work.

Doctor Livingston brings out many excellent points which deserve consideration. And in a post-discussion Bortone makes certain statements that command the attention of every surgeon. Especially pertinent is: "Is it the spinal anesthesia itself which is hazardous? I blame a good many of these deaths upon the anesthetist himself. A man who makes use of spinal anesthesia as a routine in every case, without any discrimination, has a high death rate, and condemns spinal anesthesia."

We hope these articles will be studied. We look forward to further reports embracing surveys including many hospitals and tabulating cases that number many thousands. When this is done, we will really know something about the various anesthetics and their mode of administration, and what type of anesthetic to use in certain conditions, and what is safe under certain conditions, those dangerous at times, and all other data leading to conclusive findings. When this becomes a fact and not a hope then will mortality in surgery be lessened to a certain extent.

ERRATA

In Dr. Flagg's Editorial in the December issue of The American Journal of Surgery, page 542, column 2, line 15, and page 543, column 2, line 29, the word "segregation" should read "integration." On page 543, column 2, line 8, the number of deaths from general asphyxia should read 954 instead of 934. The solution to the problem outlined by Dr. Flagg at that time will be discussed in the February issue.

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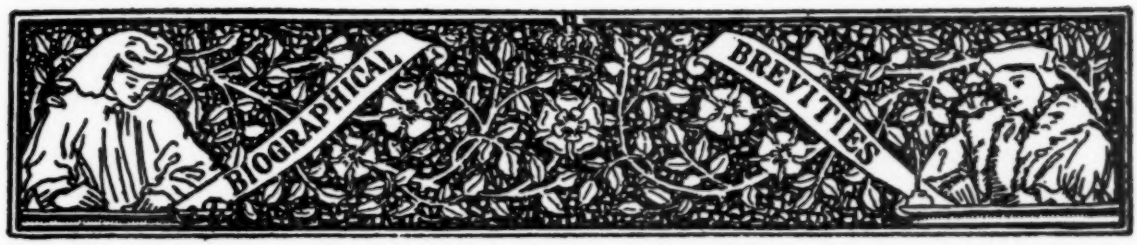
VALENTINE MOTT

[1785-1865]



AMERICAN PHYSICIANS

VALENTINE MOTT

VALENTINE MOTT, a great pioneer in vascular surgery, called the "Napoleon of Surgery," was born at Glen Cove, Long Island, N. Y., on August 20, 1785. He received his early education from a private instructor at Newton, L. I., until 1804 when he entered Columbia College. During that period he entered the office of a relative, Dr. Valentine Seaman. He received his M.D. in 1806. Following his graduation he immediately went to Europe where Sir Astley Cooper was his preceptor in anatomy and surgery. From London he went to Edinburgh and sat at the feet of Hope, Playfair and Gregory. He returned to America in 1809 and was called at once to fill the chair of Surgery in Columbia College. He continued in this position until it was merged into the College of Physicians and Surgeons (1813), and here he continued as professor until 1826, "but difficulties arising with the trustees and professors on principles of collegiate government he resigned and founded, with able associates, another nucleus of learning, designated Rutgers Medical College . . . which continued in existence four years." From 1830 on Dr. Mott lectured at the College of Physicians and Surgeons, and subsequently before the University Medical College. Here he fulfilled his mission as Ex-president of the Faculty and Emeritus Professor till his death.

Valentine Mott was the originator, in the United States, of clinical instruction in surgery. As early as 1818, when but thirty-three years old, he placed a ligature around the brachiocephalic trunk or arteria innominata, only 2 inches from the heart, for aneurysm of the right subclavian artery, for the first time in history.

His original work is best summed up in his reply to an inquiry from Dr. S. W. Francis. Dr. Mott wrote:

> At your kind request I have enclosed a list of most of my original operations. They were performed without ever having heard or read of their being done by any one before . . .
>
> Original Operations.
>
> Tying the arteria innominata.
>
> Tying the primitive iliac.
>
> Exsection of the clavicle. This is the most important and difficult operation that can be performed by man.
>
> Exsection of the lower jaw in different portions.
>
> Immobility of the lower jaw.
>
> Cutting out two inches of the deep jugular vein inseparably imbedded in a tumor, and tying both ends of the vein.
>
> Closing with a fine ligature, wounds of large veins of a longitudinal or transverse kind, and even when an olive-sliced piece has been cut out.
>
> These I have seen, and by pinching up the wound with forceps and applying a small ligature, the wound has healed without obliterating the canal of the vein. In this way I treated successfully the great axillary and the deep jugular . . .

Great honors were bestowed on Dr. Mott at home and abroad.

In his later years he suffered from angina pectoris. The news of Lincoln's death brought on an attack from which he perished at his home, No. 1 Gramercy Park, New York City, when he was in his eightieth year, on April 26, 1865.

T. S. W.

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

ULRICH VON HUTTEN

PART I

BEN WOLEPOR, M.D.

MONTREAL, CANADA

I. THE REFORMATION AND VON HUTTEN

THE Reformation was the triumph of secular authority, in a struggle with the Church, centuries old. The combat took place in city after city, from Stralsund to Geneva. The Reformation was part of the process that enabled Europe to establish herself as a conglomeration of independent secular, sovereign States. A religious revival accompanied the efforts of princes and magistrates to rule the Church and seize its wealth. Convictions, it appeared followed the money-bags. The religious revival was not limited to Protestantism alone, Catholicism participated. The Catholic Church strenuously sought to reform its discipline and administration and to define its doctrinal position. Accompanying the combat for wealth and jurisdiction were the attempts to propagate "true religion." The governments, although they tried to avoid the step, were forced to commit themselves on the ecclesiastical question and define their position. During the Reformation enormous transferences of jurisdiction and property took place. Nations faced war and knew the disastrous consequences of civil war. The governments were forced to organize their conquests and to utilize the reformed church as an instrument of their policies. Religious persecution occurred and literary controversy. The Reformation in Germany almost completely disintegrated the nation. The old rivalry between Northern and Southern Germany reappeared. Metaphysically the chief difference between the dissenters and the Roman Church was due to the question of free will. Luther's "De Servo Arbitrio" made it impossible for Erasmus to enter the Lutheran camp. Luther in 1520, in three great treatises, rejected all the claims of the Papacy. He declared that the clergy had no coercive powers whatsoever; he insisted that the clergy were subordinate to lay authority like other people. He dismissed Canon Law as one without foundation. The view that magistrates, civil and ecclesiastical, theoretically governed a united Christendom, was modified. The Reformers abolished the latter and the survivor, lay authority, ruled as the recognized dictator. Christendom was severed into a group of independent secular constituencies, the precursor of the modern state. The bishop's throne

was deprived of power that redounded to the magistrate. From now on the civil magistrate alone could reform the Church and preside as the guardian of justice and peace. The real controversy of the later Middle Ages devolved upon the crucial decision as to what the purpose and pursuits of government were to be. The words, Pope and Emperor, merely expressed familiar phraseology in a fundamental problem.

The versatile and shrewd Bodin stated that the main factor in the Reformation throughout the world was the insatiable desire to seize church property. Intelligent laymen resented clerical domination in the field of education and assumed that the clergy was obstructive and the disseminator of obscure views that prevented enlightenment. They felt that superstition was grossly utilized to deceive a credulous people and that the desires underlying these tactics were instigated for sordid purposes.

One is forced to admit that there was much expediency about the Reformation, especially in England, and eloquent prelates, induced by desperation and wishing to avoid the fate of Sir Thomas More, grew voluble in a cause whose failure meant decapitation. They may very well have admired Sir Thomas More, although he was alone, that is if one excludes his God. Even the licentious Henry VIII regretted his death.

We behold the ignoble sight of learning cowering before force and see piety, grown equivocal, grovel at the feet of a king. In the Apology of 1533, Sir Thomas More emphasized a fact that is very difficult to answer: "The Church was gathered and the faith believed," he wrote, "before ever any part of the New Testament was put in writing. And which writing was or is the true scripture, neither Luther or Tyndale knoweth but by the credence that they give to the Church. Which is this word written Tyndale cannot tell but by the Church. Why should not Luther and Tyndale as well believe the Church, in that it telleth them this thing did Christ and his Apostles say, as they must believe the Church (or else believe nothing) in that it telleth them this thing did Christ's evangelists and Apostles write."

Apparently the mystic alone was capable of that deep love of infinity and the eternal, whose flawless laws paraded themselves before man in the guise of the seasons. The average man had dimly perceived this vision during the Middle Ages, a spectacle that at times rose to the intensity of the Crusades, but love of life and a prying, gamboling curiosity made him depart from promised splendors to the glory of realization. Dante was separated from Petrarch by the seven bars of heaven and the yawning pit of hell; Petrarch, who wandered in the green field of Italy and, if he heard celestial voices, attributed them to the song of the lark.

One wonders at times as to whether the world profits very much from its geniuses; for the mass mind often distorts great messages. Confucius' advice to love one's parents becomes the burdened ancestor worship of the Chinese. Buddha's injunction for contemplation induces men to flee into the desert and live an isolated existence that is barren. The Hindus carry an humane attitude to dumb animals to the absurd extent of idolatry and die holding the tail of a sacred cow. One may choose to regard instincts as conditioned reflexes but the grooves of habit make man almost as inflexible in the processes of thought as the automatic responses of the bee and ant. Thousands of years ago the strange phenomenon of a Greek thinker arose amongst the Jews: the weary Ecclesiastes who, cynically beholding the actions of mankind, likened them to an aimless circle. We can almost hear the words, "Eat drink and be merry, for to-morrow ye die."

The genius has been stamped in the cradle by the Three Sisters, with an enduring brand. Although he possess dreams,

to achieve his birth-right he must have courage and the ability to regard failure for the impostor that it is and to rest assured in the fact that only death may justify his viewpoint. Though wretched in life he would be doubly wretched if he let this celestial seed atrophy within his heart. It must sprout, though watered with his blood. He is different and knowing it, revels in the fact, though it attract contumely. A rebel, he tends to make of the disimilar elements of mankind one and by imposing the force of his unique personality, loses self and merges in the pervasive stream of humanity. He speaks with assurance and if hesitation occurs it is but momentary and lost in the speedily ensuing vision which uplifts him.

What relationship is their between Luther and Laennec, Hutten and Pasteur? Why the stress on the Reformation any more than on the change of garments of varied centuries? There could never have been "L'auscultation médiate" without the spirit that although it consumed, yet breathed a revivifying fire, one that laid wast a mighty area only to prepare for a more luxuriant growth. The things man studies are unimportant whether they be chemistry or Latin. The importance lies in the intention that guides the spirit, its scope and unlimited trammels. To put a check upon knowledge is as detrimental as the introduction of air into veins. The circulation of truth stops. The resources of the scholasts were limited and although they were intelligent men, one cannot construct palaces of mud or ships of reeds. It was the discovery of the beauty of the fields that led to the search for the causes of tuberculosis and syphilis. Poetry preceded and nurtured science. The objects were different but the methods similar, merely vulgar curiosity enlightened by the passion that elevated this odious characteristic to the quality we call truth. Man grew bored at the insistence on celestial bliss. All systems of thought run in cycles and perish of the very facts that give them birth. Men grew weary and the climax became anticlimax, pathos declined to bathos and tragedy deteriorated into the burlesque. Other avenues of relaxation were sought. Thought is like a boulder that leaping down the mountain-side gathers an uncontrollable momentum and behold an avalanche forms that sweeps all obstacles aside! Protestantism enkindled the religious fire of Bach, or rather Bach's quest for the eternal. Each man must return God's work, for, as the Creator made man from clay, so must each mortal fashion God for himself from his own substance. The varying conceptions of the Deity are as transient in their temporary guises, although essentially eternal, as the substance which can undergo the change into liquid, solid, gas and still remain integral. The Renaissance permitted the growth of man's conception of the Creator. Petrarch saw him as clearly in the fields as Luther in the cathedral. Now and then a reckless spirit, drunk with conceit and self-righteousness, the complacency of assumed, complete knowledge and power burnt a Servetus at the stake, who differed on academical points, but as a rule the spirit of humility was working and men held the transient, furtive fear, that perhaps they would never completely understand Jehovah and his manifestations.

There is a legend amongst an ancient race, concerning the translation of language and comparing it to the pouring of a rare perfume from one flask into another. During the act of transference, some of the precious essence is dissipated into the air. A few mystics can be properly called religious, for the state is one of intoxication or abnormality corresponding to the feverish activity of the poet, painter or composer. The mass of mankind is content to follow meekly the reflection that the Deity casts upon the mirror of the prophet, for the seer enkindles amongst his followers only a semblance of intense ardor. It is evanescent and therefore his eternal complaint, though it be Isaiah, Hosea, Micah as to the coldness of the

race of man. The Renaissance was to foster new interpretations of religion and create new leaders of thought. Spinoza, in "The Ethics," was to declare the theory of uninterested forces, obeying impartial laws, a theory that clashed with the views of a personal God.

II. THE VICISSITUDES OF GENIUS

Men, at times, can only rise to greatness if their contemporaries permit it. An able inquisitor in Germany could have suppressed Luther in the beginning when he was still in the fluid state of revolt and not fixed in the dogmatic attitude of the conqueror. A stalwart Dauphin and resolute clergy of Poiters could have easily destroyed a bewitched Maid of Domremy long ere she reached the gates of Orléans; but chance, prevalent superstitions, a centripetal rush of happy circumstances, helped make even the unfit great. Genius is not only a quality of being, but a dependent of circumstance. Had Shakespeare not left Stratford and become a strolling player, he might very well have developed into an admirable business man. There are innumerable instances of great men whom posterity has forgotten, that their gifted contemporaries regarded as superior. Dante banished, became the author of "La Commedia." Milton defeated, was the writer of "Paradise Lost." Had Shelley been a normal boy and not baited by his schoolmates, his work would not have dealt with ideal states of existence (a harking back to his own unhappy youth) but with the problems of every day, the passions and lusts of mankind, as "The Cenci" reveals. It is not necessary to have the Behaviourists stress the importance of environment; history, a much more ample page, is replete with confirmatory evidence. Will is not a fountain that man turns on and off, but a stream that arises from the remote recesses of youth and its tribulations, from the caste of the individual, his aspirations, failures and further flight. There are men who have persevered without encouragement, but stability is not always a characteristic of genius, rather is it one of plodding mediocrity, which knowing no other way, pursues the common rut and prides itself on that to which it is by necessity confined.

Dante was familiar with many classical authors; his work abounds in famous Grecian names, even Thais who graced the companionship of the distinguished and gifted, grovels in a hell whose consistency plays havoc with hands that once ensnared a brilliant world. Yet the spirit of the book is medieval in its acceptance of a philosophy of submission and acquiescence. Among the tortured souls that the winds of hell assail, who whirl about like sodden leaves in an autumn tempest, are those whose cries Dante ignores in the complacent superiority of the mind cast in tradition's mould. "Perish these heretics," he cries, but their words are as eternal as their woes and penetrate the shrieking caverns of the deep, to the peaceful fields of earth, the gentle warmth of the sun and the awakening souls of men. Dante ignored the exsurgence of the ancients and their wisdom; but Petrarch listened intently, smiled inwardly at the truth he had long awaited and the age, delighted with Laura's charms, hastened to emulate the master's gifts. Learning became more than a pastime. It throve in the seats of the mighty and joined the stern ranks of commerce, the studio of the artist, the garret of the poet, the forum of the politician and the courts of the wealthy. Men were as entranced with the flood of ideas as a miser with his gold, content for the while with the gleaming spheres for their own sake. Creation, barely awakened, lay back and reposed for a generation, ere she once more wended her way amongst the populous cities. The assimilation of old treasures preceded the creation of the new. "Let us drink the old wine, it is rare and fragrant. At another spring shall we plant our vines."

Perfection, beauty, truth all mean the same thing and signify a glimpse of fulfill-

ment and are the road to its acquisition. The poet found his realization on earth, the mystic in heaven. All strove for the same object. They only differed in its abode. The theologians were so enamoured of their impression of Truth that they destroyed those whose views would shatter the prism of perfection as they saw it, and by devious arguments justified their hedonism. The eternal beatitudes, a state of perpetual bliss, the constant hovering of delight and snowy pinions were intoxicating and they burnt and tortured those who intruded on dreams made of this divine substance. Europe, like a restive steed eager for the race and straining at the barrier, had long been prepared for the dramatic change called the Renaissance. The new way of life, the new perspective, the rich, culture taken from Greece and Rome were but as the light flicks of the whip that send the fleet racer coursing down the track, eyes afire and body unleashed like a bow. The classics would not mean a repetition of old culture but only a revivifying infusion into a system of thought, ready and young and peculiar unto itself. The classics were catalytic agents; they whipped up a reaction in which all the ingredients were present. Men eager to explore require a guide. Virgil and Terence, and the authors of the original Greek version of the New Testament, arose from graves in which it seemed the very dust had long since been blown throughout the world by wandering winds. The ancient authors were resurrected and their hearts beat in new breasts and their thoughts pulsed in vigorous minds. Beauty and truth were not lost, they had only been forgotten and man, awakening from a torpid sleep, once more lived in a young and vivid springtime. Before the classics could work their potent spell, Church and Empire, fabulous ideas, semblances of reality that ruled through imagination and not actuality, had to be consumed and the development of nationalities and cohesiveness of language were necessary. The feudal system was no longer required in a world progressing beyond this barbarous system of protection, now no longer adequate. Paper was invented and books were moderate in price; printing disseminated ideas on the one hand and gunpowder a redistribution of power on the other. The restlessness sweeping Europe impinged upon the adventurous minds of mariners who sailed away over the wide seas in small vessels, whose insignificance on a mighty crest of the sea was deceptive, for they swept aside all difficulties, faced storms, the lashing winds and conquered new continents. America was discovered, and China explored, the fabulous Cathay. Wealth, gold, jewels and silks, rare spices were acquired, foreign music heard and strange dishes tasted. Heathenish tongues lured them on, for there were men with faces as yellow as ocher, with eyes as oblique as that of a cat. The widely circulated stories of these beings were exaggerated until any preposterous tale was gospel for the credulous. The compass guided man on the seas, but eager and aggressive, aspiring like the God that he is, he had turned towards the heavens, discarding the inadequate Ptolemaic system of astronomy and embraced the Copernican views. The speed is furious like that of racing steeds, thundering up the new road.

Christianity had done a great work in making men out of barbarians. The civilized Teutons, with the hardiness and restraint of a Northern race, had conquered the formerly supreme Latins and had been in turn influenced and cultured by the latter. No longer forced to fight a surly environment for daily existence, men acquired material comforts and with the acquisition of wealth, tranquillity and leisure followed. Leisure made man realize his potentialities and incited him to creation. The state was to arise and groups of states united in a common cause; federation was born, new theories of state and church replaced the long dead views of a universal monarchy and indivisible

Christendom, relics of the memory of the great Roman Empire which after hundreds of years still exerted sway on men whose ancestors once fought and marveled at Caesar. The Renaissance was the ripened fruit of which the ecclesiastical and feudal despotism had been the flower. The study of the classics spurred on the latent originality of the Middle Ages. The potentialities were there, all that was lacking was confidence in themselves; faith not only in the Deity and his representative but in their own manliness, courage and ability, learning and creativeness. The Old Masters gave them this added factor; the sources of knowledge in the Middle Ages were inadequate, Latin translations made by Jews from Arabic commentaries on Greek texts were only available. Natural laws were earthy and bore no relationship to the life hereafter. Thus the lack of spontaneity and creativeness in men who could not build pyramids because the bricks had no straw. Early revolters failed through inadequate resources: science was regarded as magic and Gerbert and Roger Bacon, scientific monks, failed to kindle anything but a feeble flame in their own cells. Their efforts were faintly successful. Dante condemned Emperor Frederick II to Hell because he had dreamt of remodelling society on a worldly basis which was a precursor of the tolerance and cultured worldliness of the Renaissance. The Church opposed his efforts and the inability of his laggard contemporaries to sense approaching events frustrated any possibility of achievement on his part. Nor were Frederick's attempts original, for he knew of the influence of the Provençal poets on Southern Europe and the ripe matured life led there. He had taken this as his model. It appeared as if feudalism and ecclesiasticism were to be shorn of power in Provençe, but the Church, still impelled by the conception of this life's unworthiness, distaste for worldly progress and delight, had organized Dominic's Inquisition, preached Simon de Montfort's crusade and destroyed the tender shoots of enlightenment. However, the Provençal poets had through versification enriched their language and made it subtle. They sought for ever varying modes of expression and tones of emotion. Europe responded to these gracious tutors with a mellow, ripening phase in her literature. Thus we have two streams of thought flowing side by side, the old and the new. Though all Christianity was absorbed in the Crusades, the forces of Naturalism and delight for the ancient vehicles of thought and emotion were being brought to bear upon humanity. The Turk was soon to become an insignificant factor; the Crusades forgotten episodes of religious wars and knowledge would ever advance. Men of the Middle Ages had at last discovered the dignity, worth and integrity of man, not as a vessel of the soul alone, but for himself. He was a sentient, reasoning creature, proud of his critical faculties and creative powers. Humanism arose, an important part of the revival of learning. The Church, whose dicta had been sacred, was now investigated for the sources of her authority, and Valla created a furore by denouncing the False Decretals and exposing the donation of Constantine to contempt, thus initiating the Reformation. Hutten seized Valla's discovery with avidity and cried "Truth," from the house tops.

In Germany only a few learned men were at first interested in humanism, but when a violent quarrel arose between the scholar Reüchlin and the Jewish Dominican, Pfefferkorn, the amused and then concerned public rallied to the defense of the press and the freedom of thought. The Reformation was the German Renaissance. The Germans were much more interested in religion than their neighbors to the south. Climate may be responsible in part for their vigorous and stern attitude. Leo X, despite his clerical affiliations, was a benevolent patron of the Renaissance until he saw the disastrous effects upon the faith of the multitude.

The Middle Ages had vitality, aggressiveness, rebelliousness, but lacked perspective. Men who hacked their way haphazardly through the wilderness needed a guide to point out the right way. They did not know how to utilize their resources of philosophy, erudition, belief and literature. If a few hardy souls attempted logical explanations, their lives were imperilled. Critical investigation, if at all pursued, was anathema.

False learning had betrayed the leaders of the world and it appeared that only the common people retained a glimmering of the proper attitude on life; a Jeanne d'Arc, a peasant girl and others like her, but they were ignorant and rarely persevered. Learning consisted in proving sanctioned premises and not in the exploration of unknown fields. Words abounded and meant nothing; but the very ingenious arguments used to support dogma gave man the versatility to destroy it later. Petrarch revealed a new method of scholarship and resurrected Humanism. He taught two things, the importance of man and that of his environment. The brilliant Italians of the 14th century listened avidly to his teachings on the study of the Latin classics and aided him in his discovery of the Greek literature. Boccaccio hnd friends went to Byzantium, the city of enlightenment and mistress of the aeritage of ancient Greece. Learning was made secure.

(To Be Continued)

BOOK REVIEWS

THE PRACTITIONER'S LIBRARY OF MEDICINE AND SURGERY, Vol. I (Anatomy and Physiology as Applied to Practical Medicine) and Vol. II (The Technic of Physical and Laboratory Examination in Clinical Medicine). Supervising Editor, George Blumer, M.A., M.D., and Associate Editors and Contributors. N. Y., D. Appleton & Co., 1932.

The Practitioner's Library of Medicine and Surgery, two volumes of which are before us, is written by young men and the needs of the general practitioner are borne in mind on every page. If the balance of the ten or twelve volumes intended to complete the work live up to the standard set by the first two, this will be one of the most invaluable series of books in the physician's library.

Volume I covers both anatomy and physiology in a concrete, concise and up-to-date manner and the illustrations leave little to be desired. Anatomy and physiology, so closely correlated, are here presented in truly modern fashion.

Volume II covers the technique of clinical medicine. The subjects are well and authoritatively covered.

The Editor in his Preface presents an almost ideal plan for this library and in the first two volumes, at least, has succeeded in living up to his ideals. A splendid index to each volume simplifies ready reference. The well-selected bibliography at the end of each chapter makes further reading an easy matter. The physician having only one modern system in his library will not go wrong in selecting this one.

MENTAL HEALERS: MESMER, EDDY, FREUD: The fourth in a series of "Master Builders" by Stefan Zweig. Trans. by Eden and Cedar Paul. N. Y., Viking Press, 1932.

This work, well translated and well printed, is of special interest to the medical man as well as the layman. It is not in any sense a history of mental healing, but rather a psychological study of three mental healers, who, working from the same general theory, have interested thousands of people. The author gives a clear picture of the central idea of self help animating, in turn, Mesmer, Mary Baker Eddy and Freud; Mesmer, by suggestion, Eddy, by "the anesthetic ecstasy of Faith" and Freud, by "unmasking the sub-conscious," thus freeing the individual, according to the old command "Know thyself."

The life story of Mary Baker Eddy and her relation to her background is told with keenness and justice, and the reader enjoys this etching of the uneducated, magnetic, strong-willed mono-maniac who started an avalanche which she could not have foreseen.

The method introduced by Freud has given us a new individual, as well as group, outlook. He, like Mesmer, started from the medical basis, but his work has profoundly affected all phases of life. Zweig gives a dynamic study of this strong fighter, now grown old, whose startling theories, whether we approve of them or not, have become an accepted part of our modern thought.

COMPENDIO DE TÉCNICA RADIOLÓGICA, RADIODIAGNÓSTICO Y RADIOTERAPIA. (Compendium of Radiologic Technic, Diagnostics and Therapy). By Doctors Otto Strauss and Otto Müller, Berlin. Trans. into Spanish by J. Cabrera of the Faculty of Sciences of Zaragoza, and J. Gay, of the Faculty of Medicine of Madrid. Madrid, Espasa-Calpe, S. A., 1931.

As the name indicates, this is a Spanish translation of an excellent German compendium of radiological technical, diagnostic and therapeutic knowledge, presented with commendable brevity, yet with surprising thoroughness. Intended for the general practitioner, this excellent handbook will no doubt appeal to many radiologists, especially those who have not yet acquired a large background of experience. Many line drawings and diagrams fully illustrate the text. Surely a very useful book for its purpose.

A HANDBOOK OF EXPERIMENTAL PATHOLOGY. By George Wagoner, M.D., and R. Philip Custer, M.D. Springfield, Ill. Charles C. Thomas, 1932.

This manual, based on the course given to the second-year students of medicine in the University of Pennsylvania, is, as its title indicates, a practical handbook of experimental pathology giving the outline of the course and the technique of the work in concise and comprehensive fashion. As Dr. Krumbhaar points out in his Foreword, there is no similar book in English. Those interested in this subject will find it necessary to have this manual at hand for reference as well as continued study.

CHILDREN'S TONSILS IN OR OUT, A CRITICAL STUDY OF THE END RESULTS OF TONSILLECTOMY. By Albert D. Kaiser, M.D. Foreword by Rush Rhees. Phila., J. B. Lippincott Co., 1932.

The author has made a very interesting survey in the past ten years in Rochester, New York of nearly 5000 children, some of whom had their tonsils removed and some not. The results of his findings are here given in great detail. His findings, like those of a great many other experienced physicians, seem to indicate that too many tonsils are removed.

This book is a distinct contribution to the perennial question of what to do with tonsils? Naturally, the final solution is not furnished but the book is worthy of careful study by those interested in the subject.

INJURIES OF THE EYE, DIAGNOSIS AND TREATMENT, FORENSIC PROCEDURES AND VISUAL ECONOMICS. By Harry Vanderbilt Wurdemann, M.D., SC.D., F.A.C.S., Ed. 2, St. Louis, C. V. Mosby Co., 1932.

An up-to-date book on injuries of the eye has been lacking for some time and this new edition of Dr. Wurdemann's book, first published in 1911, has been brought thoroughly up-to-date and covers the ground in a very satisfactory manner. The colored illustrations are worthy of particular commendation and the medicolegal aspects of this work will be found of great practical value by all physicians.

All who have anything to do with eye injuries will find this work a good one to have on their shelves.

DISEASES OF THE THYROID GLAND WITH SPECIAL REFERENCE TO THYROTOXICOSIS. By Cecil A. Joll, M.S., B.SC. (Lond.), F.R.C.S. (Eng.). St. Louis, C. V. Mosby Co., 1932.

It is interesting to note the statement in the author's preface that "No work aiming at a general survey of diseases of the thyroid apparatus and their treatment has been published in Great Britain for thirty years." This gap in British literature has certainly been filled by this volume which will be found a comprehensive and up-to-date survey of the subject. While, of course, there is much controversial matter to be considered, it is felt that this book may be safely followed as any other and it will be one of the standard guides on the subject. The illustrations are splendid, many of them being in colors. The chapter on Anaesthesia is especially interesting and up to-date.

THE COLON, RECTUM AND ANUS. By Fred W. Rankin, M.D., F.A.C.S., J. Arnold Bargen, M.D., M.S. in Med., F.A.C.P. and Louis A. Buie, M.D., F.A.C.S. Phila., W. B. Saunders Co., 1932.

This is one of the best books on diseases of the colon, rectum and anus that has appeared in English. The work shows not only an exhaustive study of the literature but also the extensive experience which the authors have obtained at the Mayo Clinic. Thoroughly comprehensive and complete, the work is so well written that it is kept down to reasonable size. There are 435 well-selected illustrations.

This volume presents the best work for both reference and study on diseases of the colon and rectum that is available at the present time.

LEHBRUCH DER UROLOGIE, mit Einschlub der Mannlichen Sexualerkrankungen. By Dr. Leopold Casper. Ed. 5, Berlin, Urban & Schwarzenberg, 1932.

The fifth edition of this famous textbook of urology brings the subject thoroughly up-to-date and will maintain the position already established for this work by previous editions. The large number of American names to be found in the author index is evidence of the widespread reading and broad point of view of the author. For those reading German, this will be found one of the most satisfactory textbooks on the subject.

ACUTE INTESTINAL OBSTRUCTION

M. A. McIVER, M.D.

FIRST INSTALLMENT

PART I: THE DISEASE

CONTENTS
[This Number]

Chapter		Vol. XIX Page
I.	Introduction	163
II.	General Considerations	172
III.	Varieties of Obstruction	191

ACUTE INTESTINAL OBSTRUCTION

PART I: THE DISEASE

CHAPTER I

INTRODUCTION

TO DEFINE concisely "acute intestinal obstruction" is impossible; for under that term, by universal consent, a number of diverse diseases or conditions are grouped. Among the characteristics which these conditions have in common, the one most consistently found is an abnormal stoppage of intestinal evacuations; and it is from this fact that the name is derived. This stoppage is not always brought about by an organic occlusion of the lumen, and, indeed, when mechanical blockage is present it is by no means always the most important element in the situation, for damage to the circulation of the bowel may be a more serious factor. Cases of intestinal obstruction, in most instances, have also in common a well-recognized set of symptoms, of which pain, vomiting and distention are the most frequently encountered; but it is only in general terms that this symptomatology can be applied to the whole group, for certain of the classical symptoms are often absent. The mode of onset of the disease, the course, intensity and total duration of the illness, show striking differences in the several types of obstruction, varying from an onset of dramatic suddenness and a course of marked intensity and brief duration, such as is found in volvulus, where the patient may be desperately ill almost from the first moment and may die within two days or less, to a most insidious beginning and relatively slow course, such as is often seen in simple blockage of the colon. Turning from the clinical picture to a consideration of the etiology and pathology, it is

apparent when the major types are contrasted that the causes are various and unrelated, and the pathological pictures completely different, as, for example, the obstructions that arise in connection with peritonitis, and those caused by blockage of the lumen.

This lack of uniformity in clinical picture, etiology and pathology creates a situation which is complicated and lends itself to misunderstanding and confusion, more especially since in spite of its very broad meaning the term intestinal obstruction is often used as though it represented a single clear-cut entity. In order to gain a comprehensive picture of the whole disease, which is essential for any intelligent application of diagnosis or treatment or for interpreting the results of experimental investigation, groups must be established of cases that may logically be considered together, and an analysis must be made of their likenesses and differences. Before attempting such a study, it will be profitable to gain some perspective by reviewing briefly the principal steps in the development of our knowledge of the disease and the methods of treatment.

Three stages leading to our present conceptions of acute intestinal obstruction may be distinguished since the beginning of the 19th century. These stages of course overlap; but in a general way they show the principal steps in development. In the first period, roughly covering the whole of the 19th century, the development centers about the study of the anatomy and pathology of the disease and the relation of these to the clinical picture. To this period belongs the recognition of the different types and causes of obstruction and the mechanism by which they come about. The foundations had been laid by the anatomists of the 17th and 18th centuries, who had become familiar with the anatomical peculiarities of most of the major types of organic occlusion but had made little or no progress in relating their morphological findings to the clinical picture. It was not until the great renaissance of medicine in the early part of the 19th century that fairly complete and sound ideas

concerning the pathology and symptomatology began to take form, and cases that today would be grouped as intestinal obstructions began to be so classified and to be withdrawn from the heterogeneous collection which included under the title of "ileus" all types of peritonitis, typhoid fever, simple colic, ascites and most cases showing persistent vomiting, abdominal distention or abdominal pain.

The culmination of this stage of development came in the last twenty-five years of the 19th century and the first decade of the 20th, when the development of abdominal surgery made possible a much better knowledge of the pathological changes occurring early in the disease and of the finer points of classification and symptomatology. The achievements of this period will be found in the works of Brinton, Leichtenstern, Bryant, Ashhurst, Fitz, Nothnagel, Gibson, Treves, and Wilms.[1–9]

The second period, starting in the latter part of the 19th century and culminating in the first quarter of the present century, is characterized by a study of the toxic factors. With the increasing number of abdominal operations and autopsies, the pathological picture presented by acute intestinal obstruction became clearer, and it was soon apparent that frequently these findings did not fully explain the acute symptoms and the prostration manifested by the patient during the illness, nor adequately account for the death that so often ensued. The search for less obvious factors which might explain the observed phenomena has centered around the belief that the course of events following intestinal obstruction could best be explained by the action of some powerful toxin. The rise of bacteriology gave stimulus and direction to the investigations. The bacterial invasion of the peritoneal cavity and blood stream was first investigated, but it was found that while this occurred in certain instances it would not account for the death of the patient in the far larger number of instances where the findings were negative. Attention was next turned to the contents of the obstructed bowel, which were obviously foul and grossly contaminated with bacteria; and it was easily proved by injecting

this material into other animals that it was usually highly toxic.

The possibility that some factor other than bacteria may be responsible for the acute illness has also been studied at length: notably, that a toxic secretion is formed by the mucosa of the obstructed bowel or that certain of the digestive ferments become toxic under conditions of obstruction. A great deal of work has been done in an attempt to isolate and identify a single, chemically pure toxin from the obstructed bowel; but while a number of substances have been isolated that proved to be highly toxic, there has been no general agreement as to their actual role in the disease.

The workers in this second period are numerous. Particularly associated with it are the names of Von Albeck, Clairmont, Roger, Murphy, Vincent, Hartwell and Hoguet, Whipple, Draper, Brooks, Sweet, and Dragstedt.[10–19]

In the third and present period, the chief interest or point of advance has been a study of the less obvious bodily changes that come about as secondary results of obstruction, especially as shown by the chemical and physical changes occurring in the blood and body fluids, notably the marked dehydration and a lowering of the blood chlorides. That these secondary effects are of great practical importance and that their correction can prove in certain instances to be a life-saving measure has been thoroughly demonstrated by Hartwell and Hoguet,[14] Haden and Orr,[20] and others. Since, however, these changes do not occur in all types of intestinal obstruction, when treatment calculated to correct them has been applied indiscriminately, the results have naturally been disappointing.

A knowledge of at least the basic facts established during these three periods, and their interrelation, is essential to anyone who is to have the clinical responsibility for patients with intestinal obstruction. The contributions of the first, or pathological, period are obviously fundamental, for as has already been pointed out, without a clear conception of the various major types of obstruction and their peculiar pathology the

picture is one of utmost confusion. During the second period, the studies of the toxic factors in the disease have thrown much light upon the bacteriology, chemical nature, mode of absorption and biological effects of the contents of the obstructed bowel, although the correct evaluation and interpretation of many of these experiments is still in doubt. The investigations made during the third period concerning the changes in the blood and body fluids that occur in certain types of obstruction and the measures that may be taken to correct them, are of first importance and can be understood only if one has a clear conception of the fundamentals of the altered physiology and the pathology in different types of obstruction.

Therapeutic measures have, of course, been influenced by all these findings; but surgical treatment has rarely followed systematically on the advance of the theoretical knowledge of a disease, and in its early beginnings was empirical and designed to relieve certain symptoms.

Attempts to treat by surgical measures cases of intestinal obstruction have from very early times to the present proceeded along two main lines: first, by indirect methods whose original object was to relieve certain symptoms, particularly distention, by draining the intestine above the point of obstruction; and second, by operations intended to find and remove the cause of the obstruction.

The most primitive of the indirect methods,—tapping the distended coils of intestine by blind puncture through the abdominal wall with a hollow needle,—goes back to very early times, when this operation (paracentesis) was used to relieve distention of the abdomen both from ascites and from accumulations in the intestine. The making of an external opening in the colon for relief of distention of that organ due to obstruction has been practiced since the beginning of the 18th century at least, for Littré[21] described this operation in 1710. A later modification by Amusatt[22] consisted in opening the colon in the left lumbar region; his name was frequently applied to this form of colostomy. It was apparently, however, not until over

a hundred years later that Dupuytren[23] established drainage from the small intestine above the point of obstruction (enterotomy*); and it remained for Nélaton,[25] whose name was usually given to the operation, in about the middle of the last century, to establish this as an accepted surgical procedure carefully thought out and executed.

The value of enterostomy was soon realized and it is in use today, modified in technique and choice of location but not in principle. Obviously, however, this procedure could usually relieve only cases of simple blockage of the bowel and did little or nothing to relieve the more frequent cases where in addition to the occlusion of the lumen there was interference with the mesenteric circulation to the involved segment.

Almost simultaneously with the employment of these indirect operations, direct attempts were made to relieve the condition by opening the abdomen and removing the obstruction. Before the days of asepsis and anesthesia, these procedures were indeed desperate adventures and of course few in number. The first reasonably authentic report was made in 1679 by Bonetus,[26] and describes an intussusception successfully reduced by a young surgeon who "had long followed the camps." About two hundred years later (1874), Ashhurst[27] was able to collect only 74 cases, in 14 of which the operation was carried out for obstruction from intussusception and in the remaining 56 for causes "other than intussusception."† Fourteen years later, however, the number of recorded cases had risen to 328;[28] and after that time, with the growth of abdominal surgery, the number of direct operations became legion.

About thirty years ago, the last edition of Treves' classical contribution, "Intestinal Obstruction," appeared. In addition to giving Treves' own contribution to the subject, this volume summarizes the work of Brinton, Leichtenstern, and others,

* Travers,[24] in 1812, stressed the value of the establishment of an intestinal fistula in cases of strangulated external hernia.

† Ashhurst's[4,27] articles carried a comprehensive and interesting account of the early history of operations for intestinal obstruction, furnishing a total list of the early cases, and a number of abstracts of the histories.

and thus may be taken as the foundation for any further treatment of the subject; the descriptions of the anatomical and pathological aspects of the disease furnished by these earlier workers are not likely to be surpassed at any time. During the last thirty years, however, important and radically new concepts of the disease and its treatment have been made. The uses and limitations of various types of surgical procedure have been revised; and a better understanding has been reached of the toxic factors in the various types of obstruction. The secondary changes that occur in the blood and body fluids as a result of the obstruction, and the importance of the prompt use of adequate amounts of physiological salt solution—the specific treatment that can correct these otherwise fatal changes—have been recognized. Supplementing this work has come a better comprehension of the importance of the inorganic chemical constituents of the digestive juices, especially of the sodium and chloride ions, and the relation that these substances bear to the subject of dehydration. The introduction of the roentgen ray has not only added to the knowledge of the motor functions of the intestinal canal, but has revolutionized the diagnosis of intestinal diseases, especially in relation to obstructions of the colon, where the use of the barium enema in connection with the *x*-ray can not only demonstrate the site of an obstruction but also lead to the early diagnosis of lesions, notably carcinoma, which if neglected would inevitably produce an acute obstruction.

In the following chapters an attempt is made to present the new concepts of the disease and to interpret the results of the important recent investigations in relation to the clinical field.

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Chapter II

GENERAL CONSIDERATIONS

Cases of acute intestinal obstruction must be considered first in two main groups which differ completely from each other in etiology and show considerable variations in symptomatology and pathology: first, obstructions due to mechanical factors; second, those of functional origin.

The old word "ileus," as a term for intestinal obstruction, is not used in this monograph. In the early days it was used to denote a heterogeneous list of abdominal diseases; there still is not complete agreement as to its use, and there is a tendency on the part of certain authors to discard the term.[1] When it is used it is generally subdivided as follows[2]:

Mechanical obstructions	Mechanical ileus
Functional obstructions	Paralytic obstructions; absence of peristalsis = Adynamic ileus
	Spastic tonic condition of intestinal musculature = Dynamic ileus

Some writers,[1] however, refer to mechanical obstruction as "adynamic ileus"; while other authors use the term "ileus" simply to refer to the paralytic obstructions. The terminology that will be used in the remainder of this volume will be "mechanical obstructions" and "functional obstructions," the latter being subdivided into paralytic and spastic obstructions.

The group of mechanical obstructions, with which this book chiefly deals, is a more clear-cut entity than the group of functional obstructions; it is much more frequently encountered and is, generally speaking, a more serious disease. Into

the group of obstructions due to functional disturbances of intestinal motility is gathered a somewhat ill-defined collection of cases, the etiology and pathology of which are not very thoroughly understood. These cases are by no means to be disregarded, however, for they often present grave difficulties in diagnosis and treatment.

Causes of Mechanical Obstructions

Mechanical obstructions of the intestinal canal come about in a number of quite dissimilar ways. The bowel may be occluded by pressure from without, as, for example, by a constricting band. Or, the occluding element may lie within the lumen as it does in obstructions caused by neoplasms or foreign bodies. A quite different mode of occlusion is found where the intestine is twisted or kinked in such a manner that the lumen is obliterated, the so-called volvulus. And still another method is represented by the intussusceptions, where the intestine is occluded by a process of in vagination within itself.

While the exact pathology found in different types of mechanical obstruction varies widely, the conditions fundamentally responsible for most of the acute obstructions are: developmental defects, inflammatory reactions within the peritoneal cavity, and neoplasms.

Under the heading of developmental defects come, first, the obstructions of early infancy due to imperfect development of the digestive tract, as, for example, atresias and other anomalies of this class[3,4]; and, second, the obstructions coming on later in life as a result of developmental structures or anomalies within the abdominal cavity, such as Meckel's diverticulum, remnants of the urachus, the appendix, congenital bands, ileocecal[5] and mesenteric cysts,[6] ectopic spleen,[7] and so forth. Congenital anomalies of the mesentery and abnormalities of intestinal rotation may at times be responsible for obstructions.[8–10] The large group of obstructions caused by hernias must also fundamentally be considered as resulting from developmental defects.

That inflammatory reactions in the peritoneal cavity are responsible either directly or indirectly for a large group of obstructions is obvious. The bands, adhesions, inflammatory

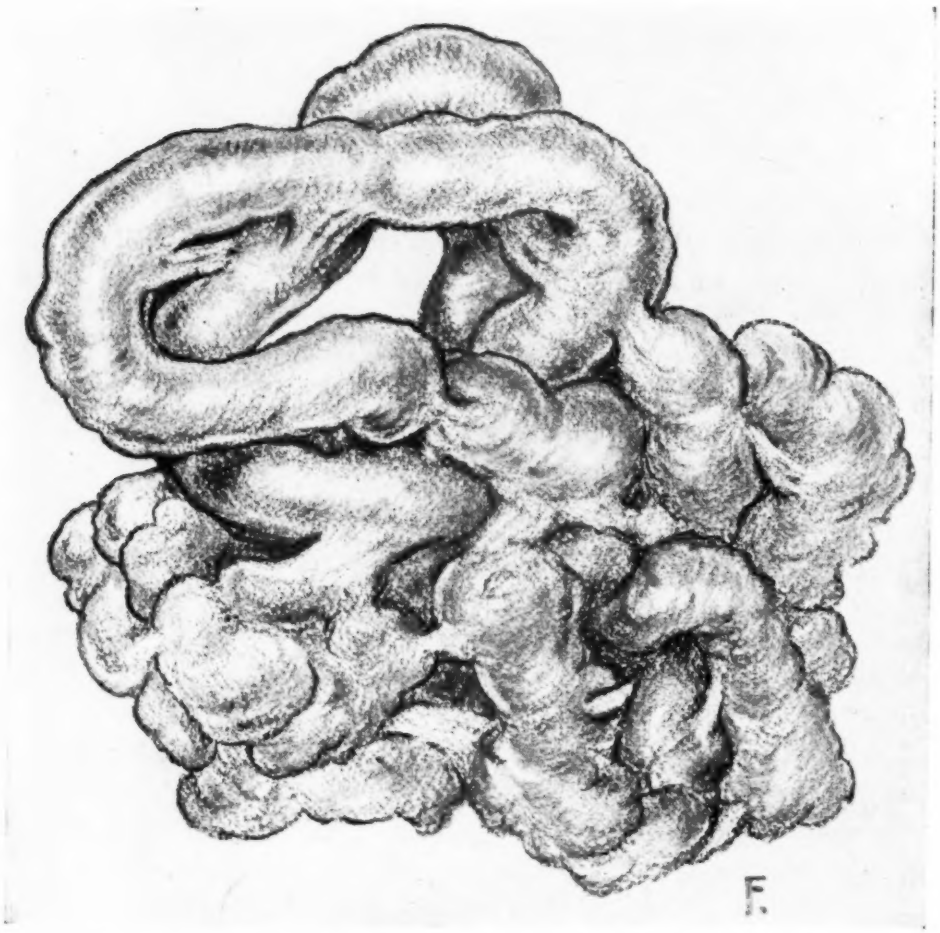

FIG. 1. Numerous bands and adhesions between loops of small intestine.
This patient had a duodenal ulcer and also sub-acute obstruction. Bands and adhesions were due to a healed peritonitis, etiology of which was uncertain.

lymph glands, etc., that arise from this cause are the result not only of bacterial inflammation of the peritoneum but also of mechanical injury, usually incidental to abdominal operations. During the last forty years that have marked the rise of

abdominal surgery, obstructions following laparotomies have formed an increasingly large proportion of the total cases[11]; (see Table XVIII, Part II*). Chronic ulcerative processes, usually tuberculous,[12] rarely syphilitic,[13] involving the bowel wall itself may lead to a stricture of the intestines and subsequent obstruction. Obstructions of this type are usually subacute or chronic; but occasionally the blockage may be complete, or a foreign body may become impacted in the narrowed lumen and convert a chronic into an acute obstruction. Benign strictures may result also from the inflammatory changes following serious interference to the mesenteric blood supply. At times, although the intestinal loop survive, an extensive inflammatory reaction may be set up and the gut wall be converted into scar tissue, with marked narrowing of the lumen.[14]

The third fundamental cause is neoplasms, which in the great majority of cases actually rise from the bowel itself and usually cause the obstruction by producing stenosis of the lumen. Since cancer of the colon makes up the great majority of all tumors of the intestine, obstructions from neoplasms are usually found in the large intestine.

Classification of Cases

In order to consider the various types of obstruction in detail, some grouping of cases is necessary. Different clinics have adopted different methods, no one of which alone is completely satisfactory. The following classification, based partly on etiology and partly on clinical features, has been in use at the Massachusetts General Hospital for thirty years or more,[15–17] and is adopted here as affording a working basis:

Obstruction by bands and adhesions, occurring:
- Early after operation
- Late after operation
- Without previous operation

Obstruction by volvulus

* This will appear in a future issue of the JOURNAL.

Obstruction by intussusception
Obstruction by rarer causes:
    Congenital anomalies
    Gallstones and other foreign bodies
    Internal hernias
    Meckel's diverticulum
Obstruction by mesenteric thrombosis and other vascular lesions
Obstruction by neoplasms
Obstruction by strangulated external hernias.

Incidence of the Various Types of Obstruction

The incidence of the various types of obstruction already outlined is shown, for a series of 335 cases recently studied,[17] in Figure 2.

It will be observed that strangulated external hernia is the etiological factor in almost one-half the total number of cases; bands and adhesions are the cause of another large group; neoplasms are responsible for a third; intussusceptions and volvuli come next; while the remaining cases are in the rarer groups.

The figures from different clinics are of interest, but some difficulty is encountered in trying to make a composite picture of the incidence of the different types. The term "intestinal obstruction" is such a broad one that different investigators may limit their studies at different points: one, for example, may exclude obstructions from carcinomas; another may omit cases complicated by peritonitis; or, again, the same cases may be grouped together on a different basis. The points of difference in selection and grouping of cases are illustrated by Table 1, which gives the classifications employed in various large clinics. It will be noted that Braun and Wortmann omit strangulated external hernias from their series. There is also a difference in the consideration of the important group of obstructions complicated by peritonitis: many of these cases

present particular difficulties in classification because there is often both a functional and a mechanical element and it is hard to say which predominates. Braun and Wortmann group

INCIDENCE OF TYPES OF OBSTRUCTION IN A TEN-YEAR SERIES OF CASES AT MASSACHUSETTS GENERAL HOSPITAL

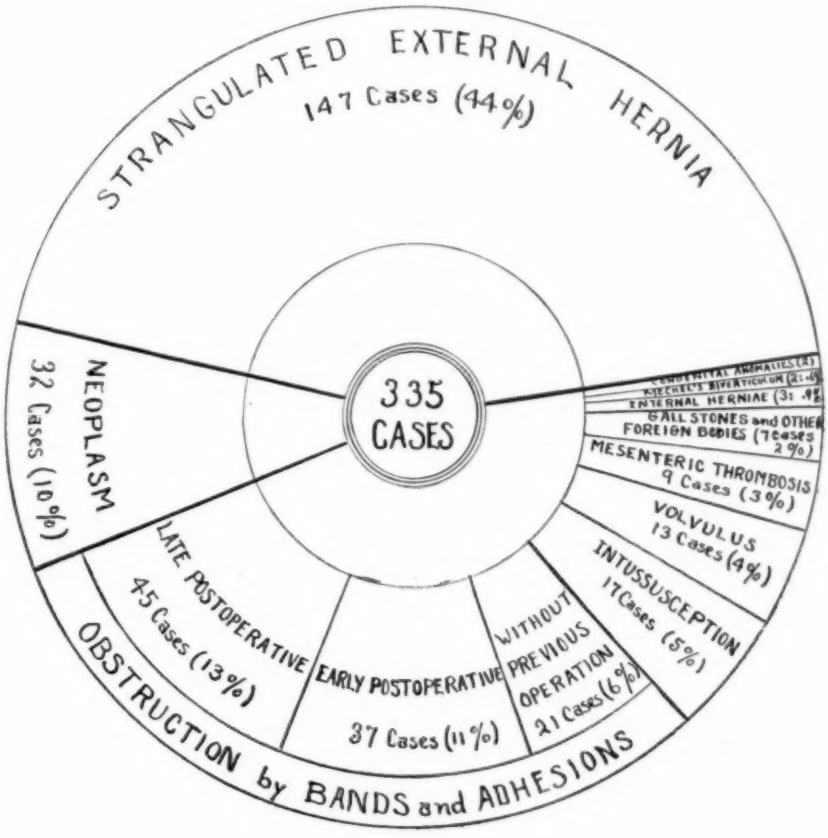

FIG. 2.

It will be observed that strangulated external hernia was the etiological factor in almost one-half the total number of cases; bands and adhesions were the cause of another large group; neoplasms were responsible for a third; intussusceptions and volvuli came next; while the remaining cases were in the rarer groups. (McIver[17])

obstructions with peritonitis separately. In the figures from the Massachusetts General Hospital, cases of peritonitis with the paralytic, functional type of obstruction are excluded; a certain number of cases, however, where peritonitis was present as a complication but where the mechanical factor of inflamma-

tory adhesions was the important element, have been included under "early postoperative obstructions." Souttar makes no mention of peritonitis in his table.

TABLE I

INCIDENCE OF VARIETIES OF OBSTRUCTION AT DIFFERENT CLINICS

Massachusetts General Hospital 1918–1927		Statistics by Braun and Wortmann, Berlin, 1903–1922		Combined Statistics from Seven London Hospitals, Reported by Souttar in 1925	
Type of Case	*Number of Cases*	*Type of Case*	*Number* of Cases*	*Type of Case*	*Number of Cases*
Early Postoperative (bands and adhesions)	37 (11%)	Obstruction with Peritonitis	44		
Late Postoperative (bands and adhesions)	45	Bendings, Kinks, etc.	94	Adhesions	342
Bands and Adhesions without previous op.	21 (20%)	Intestinal knots	4	Internal strangulation	223 (18%)
		Strangulation†	64		
Internal Hernias	3 (1%)	Hernias, internal and diaphragmatic	8	(Internal hernias incl. under above)	
Volvulus	13 (4%)	Volvulus	63	Volvulus	74 (2%)
Intussusception	17 (5%)	Invagination	43	Intussusception§	630 (21%)
Gallstones and Other Foreign Bodies	7 (2%)	Gallstones	7	Gallstones	28 (1%)
Mesenteric Thrombosis	9 (3%)				
Congenital Anomalies	2 (1%)				
Meckel's diverticulum	2 (1%)				
Neoplasms	32 (9%)	Carcinoma of the large intestine	48	Carcinoma	358 (11%)
Strangulated External Hernias	147 (44%)	.....	...	Hernias	1409 (46%)
		Inflammatory stricture of small intestine	4		
Totals	335	.....	379	.....	3064

* Strangulated external hernias are not included in the series of Braun and Wortmann; since, therefore, the percentages would not be comparable with those of the other two series, they are not given.

† Strangulations are divided by Braun and Wortmann into two groups: "Strangeinklemmungen" (54) and "Strangabklemmungen"(10).

§ Souttar divides his intussusceptions into those with tumors (17) and those without (613).

There are four groups that are usually given the same titles: volvulus, intussusception, tumors (or carcinomas) and gallstones. It will be noted in Table 1 that the percentage incidence of the two latter types at the different hospitals is fairly uniform. From the literature one has the impression that volvulus is more common in the European clinics than in this country; and this is borne out by the figures of this table. The high percentage of intussusceptions reported by Souttar is explained by the fact that intussusception is predominantly a disease of infancy and early childhood, and the number of cases reported in any series will be influenced by the ratio of adults to children admitted to the clinic furnishing the figures.

Distribution of Cases by Age

Figure 3 illustrates the incidence of the different varieties of obstruction at different ages, and brings out certain interesting points.

It will be noted that obstructions from congenital anomalies and from intussusceptions occur for the most part in infancy and childhood. Obstructions arising from bands and adhesions in patients not previously operated upon showed, in this series, two definite peaks: one in the second and third decades and another in old age, middle life being relatively free; this is a rather striking finding, but may be simply a coincidence in this small group. Bands and adhesions occurring either early or late after operation are found for the most part in young adults or those in middle age, corresponding to the period of greatest frequency of abdominal operations. Mesenteric thromboses and other circulatory lesions reach their peak in old age, although cases do occur as early as the third decade. Obstructions from neoplasms as might be expected reach their peak in old age. In the group of strangulated external hernias, while all ages are represented, a very striking peak occurs in the fifth and sixth decades; and while there is no actual peak in early childhood, it is interesting to note that except for congenital anomalies and intussusceptions strangulated external hernia is

DISTRIBUTION OF VARIOUS TYPES OF OBSTRUCTION ACCORDING TO AGE OF PATIENT

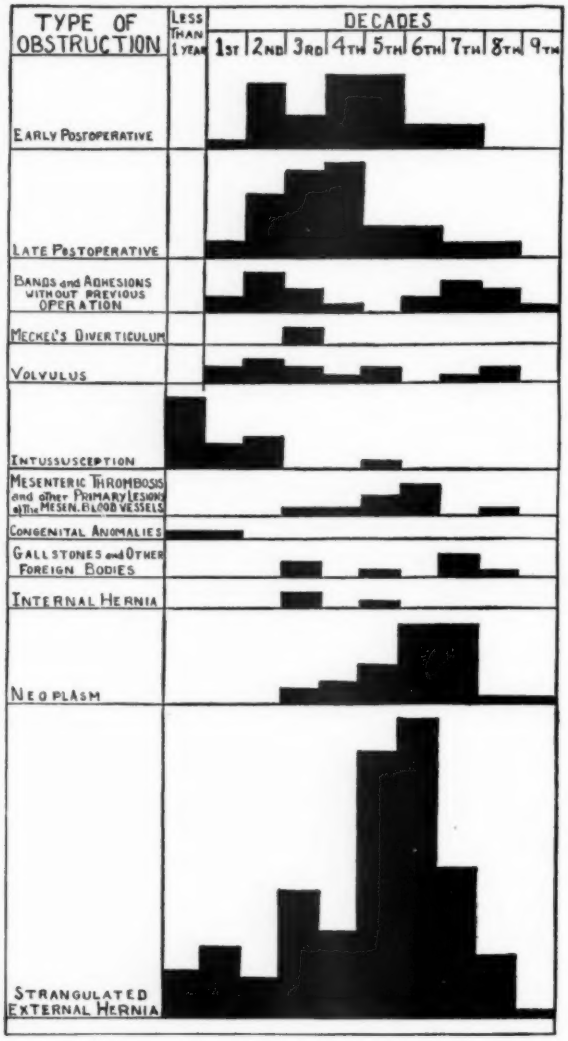

FIG. 3.

It will be noted that obstructions from bands and adhesions occur for the most part in young adults and those of middle age. Mesenteric thromboses and other circulatory lesions reach their peak in old age. Obstructions from neoplasms, as might be expected, also occur for the most part after the fifth decade. In the group of strangulated external hernias, while all ages are represented, a very striking peak occurs in the fifth and sixth decades; and while there is no actual peak in early childhood, it is interesting to note that except for congenital anomalies and intussusceptions, strangulated hernia was the only cause, in this series, of obstruction in the first year of life. Intussusceptions occur almost entirely in infancy and early childhood. (McIver[17])

the only cause, in this series, of obstruction in the first year of life.

Distribution by Sex and Race

Intestinal obstruction occurs far more frequently in males than in females. In the series of cases recently studied at the Massachusetts General Hospital there were 216 males and 119 females. Among all the varieties there was only one group in which the obstruction occurred appreciably more often in females than in males, namely the group of "gallstones and other foreign bodies," where there were only 2 males and 5 females.

Acute intestinal obstruction is somewhat more common in the negro race than in the white.[20,21] This is possibly related to the fact that keloid formations are more common in negroes.

Important Factors Affecting All Types of Mechanical Obstruction

Before going on to a detailed analysis of the different types of mechanical obstruction, two factors which largely determine the nature of the disease in each particular case may be considered. These are, first, the condition of the circulation of the bowel; and, second, the level of the obstruction.

Circulation to the Bowel. It must be emphasized that the most important factor governing the pathology and symptomatology, and largely determining the severity of the illness, is, paradoxically enough, not the blockage of the intestinal stream but the condition of the circulation to the involved segment of bowel. Interference with the circulation of the bowel may come about in two ways. First there may be gross interference with the mesenteric circulation (strangulation); second, the capillary circulation in the wall of the bowel itself may be damaged by the increased intraintestinal pressure of extreme distention.

Mesenteric Circulation. It is necessary to remember that the blood supply to a great part of the bowel is vulnerable:

the free motility of large portions of the intestinal tract is due in part to the fact that the intestine is attached to the posterior abdominal wall by the delicate web-like mesentery which

FIG. 4. Strangulation by a constricting band; gangrene of involved loop. (After Braun and Wortmann[18])

carries but affords little protection to the arteries and veins supplying the intestinal circulation. From the point of view of function, the mesentery is as much a part of the intestinal tract as the air-line is of a diver's suit, and the compression of either is equally disastrous. This grouping of the mesentery and the intestine together is of great practical importance, for most of the twists, knots, invaginations and strangulations that obstruct the intestinal lumen also in varying degrees snarl or compress the mesentery.

In cases of obstruction where the mesenteric circulation is impaired, the severity of the illness is, broadly speaking, proportional to the degree of interference. Where the interfer-

ence is extensive, the course of the disease is fulminating in the extreme and the pathology and the alterations of the physiology are quite different from what they are in cases where there is merely blockage of the intestinal lumen; there is little time for secondary effects, such, for example, as would result from the loss of digestive secretions by vomiting. If the obstruction is not relieved, the patient dies of a toxemia or a general peritonitis, and at autopsy gross changes in the bowel wall are observed (Fig. 4). The more serious nature of this type of obstruction, usually termed "strangulation," as contrasted with simple obstruction has been an established fact in the surgical literature for a long time, having been accurately summarized in 1885 by Bryant.*[22]

Table II, A and B, shows the incidence and effect on mortality of interference with the circulation in 335 cases of acute intestinal obstruction. It will be noted that 66 of the 156 cases listed in Table II, A, showed some degree of interference with the mesenteric circulation, although in many instances this was not extreme, and that the mortality among these patients was 53 per cent as contrasted with a mortality of 37 per cent in patients without this complication. In Table III (comprising the same types of obstruction as those in Table II, A), it will be seen that about half the patients with intestinal obstruction in a thirty-year period had interference with the mesenteric circulation, and that the mortality was 62 per cent as con-

*Bryant writes: "Hitherto it has been the custom to place cases of strangulation of the bowel amongst those of obstruction, indeed, to consider them as only one of its forms. There is, I am convinced, in this arrangement a grievous error; since, in strangulation of the intestine, obstruction is only one of its symptoms, but not the cause of danger or of death; whereas, in cases of intestinal obstruction, the obstruction is the prominent and dangerous feature, and from it, or it chiefly, the consecutive changes are brought about."

And again: "In fact, in this instance, as, in all other cases of acute or a like nature (strangulation), the symptoms are directly due to the arrest of the circulation of the venous blood through the strangulated bowel, and not to the obstruction to the passage of the intestinal contents. The action of the bowels may, as a clinical symptom, be one of value to prove the patency of the intestinal tract, and to suggest, consequently, the completed removal of the cause of the strangulation; but it is well to remember that the symptoms excited by strangulation of the bowel are not due to obstruction alone."

trasted with a mortality of 41 per cent among patients where the mesenteric blood supply was not disturbed. It is interesting to note in this table that the proportion of patients having this serious complication was about the same in the three ten-year periods.

Among the obstructions by neoplasm (Table II, B) only one case showed interference with the mesenteric circulation. This is due, of course, to the fact that in the great majority of these cases the obstruction comes about through blockage of the lumen by a growth originating within the bowel wall.

All the cases due to strangulated external hernia (Table II, B), by definition, showed some degree of interference with the mesenteric circulation. These cases, however, from the point of view of early diagnosis, ease of management, and absorption from the involved loop, present features distinctive from internal strangulations and are discussed in detail later.

TABLE II

INTERFERENCE WITH MESENTERIC CIRCULATION

A

Classification	*Number of Cases*	*Number Showing Interference with Circulation*	*Mortality in Cases with Interference (Per Cent)*	*Mortality Cases without Interference (Per Cent)*
Postoperative, early	37	2 (5%)	100	43
Postoperative, late	45	17 (38%)	29	28
Bands and Adhesions Without Previous Operation	21	8 (38%)	50	38
Meckel's Diverticulum	2	2 (100%)	0	0
Volvulus	13	9 (69%)	55	25
Intussusception	17	17 (100%)	53	0
Mesenteric Thrombosis	9	9 (100%)	100	0
Congenital Anomaly	2	0	0	100
Gallstones and other Foreign Bodies	7	0	0	29
Strangulated Internal Hernias	3	2 (67%)	50	0
Total	156	66 (42%)	53	37

TABLE II. (*Continued*)

B

Classification	*Number of Cases*	*Number Showing Interference with Circulation*	*Mortality in Cases with Interference (Per Cent)*	*Mortality Cases without Interference (Per Cent)*
Neoplasms	32	1* (3%)	100	28
Strangulated External Hernias	147	147 (100%)	18	0

* There were also 2 cases where neoplasm caused mesenteric thrombosis; these are listed under that heading.

Table II shows the number of cases in the various types of obstruction in which there was interference with the mesenteric circulation, and its effect upon the severity of the disease. It will be noted that in the obstructions occurring early after operation this complication is relatively infrequent; it is also rare in obstructions by neoplasms.

It will be observed that the mortality in strangulated external hernias is low in spite of the fact that there is interference with the mesenteric circulation in every case. In this type of obstruction there are certain other important factors, to be discussed later, which account for the lower mortality. (McIver[17])

TABLE III

INTERFERENCE WITH THE MESENTERIC CIRCULATION, THIRTY-YEAR PERIOD (ALL CASES OF ACUTE OBSTRUCTION EXCEPT THOSE DUE TO EXTERNAL STRANGULATED HERNIA AND NEOPLASM)

Period	*Number of Cases*	*Number Showing Interference with Mesenteric Circulation*	*Mortality in Cases with Interference (Per Cent)*	*Mortality in Cases without Interference (Per Cent)*
1898–1907	121	59 (49%)	78	57
1908–1917	118	54 (45%)	55	30
1918–1927	156	66 (42%)	53	37
Total	395	179 (45%)	62	41

This table again illustrates the higher mortality shown by cases of obstruction complicated by interference with the mesenteric circulation. (Scudder,[15] Richardson[16] and McIver[17])

Circulation in the Bowel Wall. The small blood vessels coursing in the relatively thin bowel walls are subject to considerable distortion when distention occurs, and the circulation is correspondingly impaired. The view that increased pressure impairs the circulation and causes subsequent damage to the bowel wall is old, having been strongly advocated in 1898 by

Kocher.[23] The dusky and at times markedly cyanotic appearance of the distended intestine constitutes a striking finding at operation. When the capillary circulation is damaged degenerative changes occur in the gut and have been reported both following experimental obstructions and at autopsies on humans.[24,25] Van Beuren[25] points out that any increase in the diameter of the bowel is tripled in the circumferential measurement. It is obvious, therefore, that severe degrees of distention result in great thinning of the intestinal wall, with stretching and flattening of its blood vessels,—the maximum interference with the circulation occurring on the antimesenteric border, where areas of infarction and perforation may at times result.

Great distention often accompanies obstruction of the colon by neoplasm. This is particularly true in obstructions of the sigmoid when partial obstruction has existed for some time before becoming complete. In these cases the cecum is particularly likely to suffer from the effects of distention, areas of necrosis and perforation occurring on the anterior surface where the circulation is most vulnerable. In the 32 obstructions from neoplasms listed in Table II, B, there were 4 cases in which there was obvious damage from distention, perforation or the beginning of necrosis of the cecum being found at operation. The interference with the circulation in the bowel wall is undoubtedly of importance also in those cases where it has not progressed to the extent of producing areas of infarction or gangrene, and may be an important factor in producing damage to the mucosa, which may in turn permit absorption of some toxic substance from the obstructed intestine. It is often difficult to estimate grossly the extent of this interference. Among 156 cases shown in Table II, A, for example, while 66 cases showed interference with the mesenteric circulation, there were only 9 instances in which it was evident from the description of the bowel at operation that extensive damage to the capillary circulation in the wall had resulted from distention; in 4 of these cases, bloody peritoneal fluid was found at operation. Interference with the capillary circulation of the bowel

wall, however, is probably an important factor in a larger proportion of cases than is indicated by these figures.

Level of the Obstruction. In the group of cases where there is simple obstruction of the lumen of the intestine and the mesenteric circulation is intact, the marked variations in the course of the disease are largely determined by the anatomical level of the obstruction in the intestine, particularly with reference to its location in the large or the small intestine.

When one considers the great differences in the more obvious functions of the several parts of the gastrointestinal tract, it seems reasonable that occlusion of one part should result in a train of events quite different from that following occlusion in another portion. For example, into the upper part of the small intestine an enormous amount of digestive secretions containing sodium and chloride ions of vital importance is poured during the course of twenty-four hours,—an amount, as will be shown later, probably equal in volume to that of the total circulating blood. If, therefore, occlusion occurs high in the intestinal tract, these fluids and electrolytes can of course not be absorbed in the lower portion; and frequently they are lost from the body in the excessive vomiting which is likely to take place. The loss of these fluids and salts is serious. In obstructions of the colon, on the other hand, in the early stages at least, absorption from the small intestine can go on to some extent and vomiting is not likely to take place in large amounts; in the colon, furthermore, all degrees of stagnation of fecal material occur more or less normally, so that adaptation to conditions of obstruction can take place more adequately and be carried on for a longer period of time. It is, therefore, natural that the illness produced by a simple obstruction of the colon is likely to run a longer, less severe course than an obstruction located in the small intestine.* Broadly speaking, but not

* The clinical difference between obstructions located in the large and in the small intestine has been recognized for a long time. Brinton[26] wrote in 1867: "On the whole, it may be safely affirmed that obstruction in the small intestine runs a more rapid course, is marked by symptoms of greater severity, and is attended with greater danger, than when located in the large intestine. It is easy to understand this contrast, though diffi-

invariably, it is also true that obstructions located in the lower ileum do not cause as fulminating an illness as those located in the jejunum or duodenum*; but while one can usually differentiate clinically between an obstruction in the colon and one in the small intestine, it is usually difficult or impossible, except in a most general way, to attempt on the basis of signs and

TABLE IV
LEVEL OF THE OBSTRUCTION

Part of Bowel Obstructed	*Classification of Cases*				
	*Group I**	*Group II*	*Group III*	*Total Cases*	
Jejunum	7	1	0	8 (2%)	249 (74%)
Ileum	59	2	0	61 (18%)	
Small Intestine (not further specified)	53	0	127	180 (54%)	
Ileocolic Intussusception	14	0	0	14 (4%)	27 (8%)
Large & Small Intestines	0	0	13	13 (4%)	
Large Intestine	16	29	7	52 (16%)	
Not Determined	7	0	0	7 (2%)	
Totals	156	32	147	335	

* Group I : All cases except those due to neoplasms or strangulated external hernias.
Group II : Obstructions due to neoplasms.
Group III: Obstructions due to strangulated external hernias.

Table IV shows the portion of the bowel obstructed. It will be noted that in 74 per cent of the cases the point of obstruction was located in the small intestine; these obstructions were for the most part in the lower small intestine; there were only 8 cases in which the obstruction was located in the jejunum. Both the large and the small intestine were involved in 8 per cent of the cases; the large intestine alone in 16 per cent. (McIver[17])

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cult adequately to resolve it into all its elements. Not only has the large intestine functions which are less complex, less delicate, and less indispensable to life than those of the jejunum and ileum, but even its greater size and mechanical distensibility, perhaps also its special powers of absorbing liquids, render its mere obstruction of less moment;—we may almost say, less divergent from its normal condition."

* In the experimental work with dogs there is often an extraordinary difference between obstruction in the upper and in the lower portion of the small intestine; high obstruction produces death in a few days, the animals with low obstruction living much longer. This has colored the statements in regard to human cases where the differences are not so well defined.

symptoms to determine the level of an obstruction of the small intestine.

Table IV shows the distribution of the obstructions at different levels of the intestine in a series of 335 cases. The number of cases occurring in the small intestine was 249; in the large and small intestine together, 27; in the colon, 52. Of those in the colon, 29 were caused by neoplasms. There is one group of high obstructions occurring in connection with a posterior gastroenterostomy, in which either the distal or the proximal loop of the upper jejunum that was used for the anastomosis becomes obstructed. These cases are by rather universal consent not grouped under the ordinary headings of acute intestinal obstructions but are described as "malfunctioning posterior gastroenterostomies" or "vicious circle after posterior gastroenterostomy."* If these cases were included in the series in Table IV, the total percentage of high obstructions would be in the neighborhood of 6 per cent instead of 2 per cent; but even so, the frequency of high obstructions is relatively low.

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*These are probably the most comparable to experimental simple, high obstructions.

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Chapter III

VARIETIES OF OBSTRUCTION

Obstruction by Bands and Adhesions

Etiology and Pathology. When the etiology of the bands and adhesions within the peritoneal cavity is considered, it may be said in general that these structures either are congenital

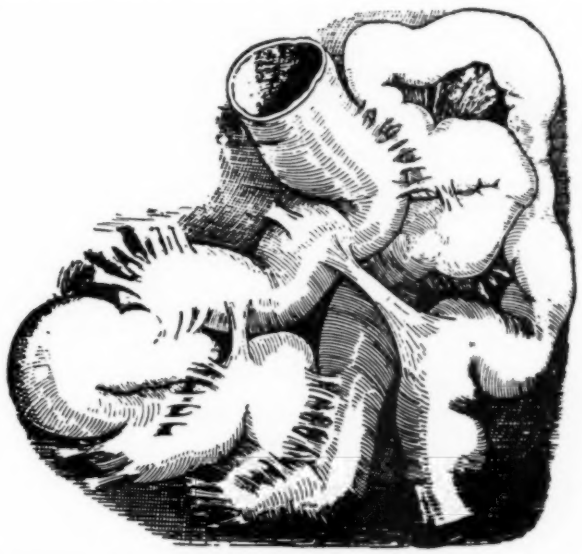

Fig. 5. Numerous dense bands binding loops of intestine to one another.

in origin or come about as a result of injury to the peritoneum; or that both these causes play a role: for example, a Meckel's diverticulum may become adherent as a result of inflammation.

Bands and adhesions arising as a result of injury to the peritoneum may be caused by bacterial inflammation or by mechanical trauma. The character of the adhesions differs according to their age. The fibrous exudate thrown out immediately after a peritoneal injury glues the intestinal coils together lightly; but even in this stage may cause obstructions. These have such distinctive features that they are considered in a separate chapter under the heading "Early Postoperative

Obstructions." In many instances these soft, fibrinous adhesions are in great part absorbed without undergoing the process of organization into fibrous tissue; but often they are converted

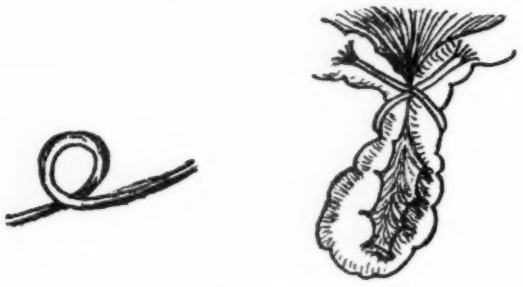

FIG. 6A.

Snaring of a loop of intestine by a long lax band attached at both ends. Band lies as a ring; loop becomes accidentally engaged and is then strangulated. (Leichtenstern[12])

into connective tissue, varying from a few light membranous attachments to very dense scar tissue and hard cicatricial bands (Fig. 5), present everywhere throughout the peritoneal cavity and binding the abdominal viscera to each other and to the abdominal wall so tightly that practically no free peritoneal cavity can be demonstrated on abdominal section. Dowd[2] points out that occasionally a chronic peritonitis occurs which affects the visceral peritoneum and resembles in certain respects the pathology found in chronic multiple serositis. The exact factors that determine how much scar tissue shall remain after injury to the peritoneum are for the most part unknown. It is recognized that the response of the peritoneum to injury differs greatly in different individuals: in some patients very slight trauma is apparently responsible for very numerous and dense adhesions; while in others, although a severe peritonitis has occurred, later abdominal section may reveal very little evidence of the previous disease.

In the main, the old, well-organized bands and adhesions have two principal forms: membranous folds or sheets; and isolated cord-like structures that are known as bands or false ligaments. According to Treves,[3] the bands may be brought about by molding and stretching of an unformed mass of

adhesive tissue into a cord by movements of the abdominal viscera, the intestines rolling over and under and about an adherent membrane until it is molded almost as a piece of clay

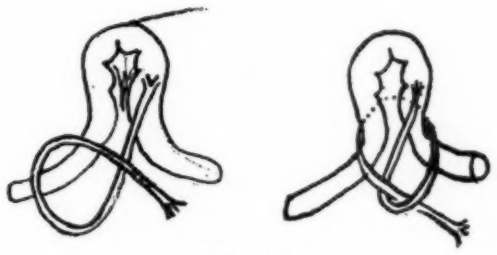

FIG. 6B.

Strangulation by a simple knot. Long loose band is fastened at one end to intestine and hangs as a simple coil (A); top of loop passes through coil, forming a knot (B). (Leichtenstern[12])

FIG. 6C.

A more complicated form of knot. (Leichtenstern[12])

may be molded when rubbed between the palms. This formation is most likely to come about when the situation of the adhesions is such as to keep the membrane on the stretch. These structures may be only small filaments, or may be dense, strong cords; they may be short pedicles binding coils of intestines to adjacent structures; or they may be long, extending from one side of the abdomen to the other. They may arise from localized areas of peritonitis, such, for example, as is caused by the breaking down of tuberculous lymph nodes; or the presence of an intestinal ulcer may furnish the localized peritoneal inflammation which is the starting point for the band.

The omentum, becoming adherent to some of the abdominal viscera, may not infrequently be converted into a band or cord

by some such process as described for the conversion of adhesions into cords.

Another structure capable of acting as a band is Meckel's

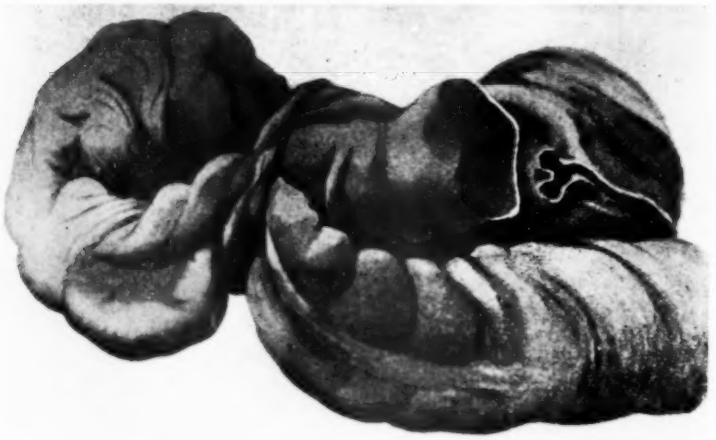

FIG. 7. Obstruction by appendix, acting as solitary band.

diverticulum. Although at times the omphalomesenteric duct may have been so completely obliterated that there is no true diverticulum, nevertheless the obliterated duct or the remains of its vessels may exist in the form of a cord stretching from the lower ileum to the umbilicus; according to Leichtenstern,[4] remains of this embryonic structure may also be represented by a band running from the ileum to the root of the mesentery. The most common condition that converts Meckel's diverticulum into a band is a local inflammatory process which anchors the free end of the diverticulum to the mesentery or to some other abdominal structure. In rare instances, when the diverticulum is long, it may form knots and thus snare loops of intestine.

The remains of other congenital or developmental structures found within the abdominal cavity may at times act as bands. The appendix (Fig. 7), fallopian tubes, appendices epiploicae or pedunculated tumors may also act as bands by becoming attached through inflammatory processes.

MECHANISM OF SIMPLE OBSTRUCTIONS AND STRANGULATIONS. Bands and adhesions bring about the actual obstruction in a number of different ways, and the pathological picture may be exceedingly complex and interesting. The subject is thoroughly covered in the works of Brinton,[6] Leichtenstern,[7] Treves,[3] Wilms,[8] and other writers of the 19th century by detailed descriptions and numerous illustrations of the pathological anatomy; for the various compressions, twists, kinks and strangulations that may be found at operation or autopsy were of particular interest to the pathologists, anatomists and surgeons during this period.

In addition to obstruction of the lumen caused by bands and adhesions, there is frequently a constriction or compression of the mesentery, which may vary from a mere slowing of the venous return to complete occlusion of the circulation. The changes in the bowel wall of course depend upon the extent of the damage to the vascular supply, and may vary from simple congestion, edema and cyanosis to complete infarction and gangrene. (Fig. 4, p. 184). The importance of this factor has already been discussed in Chapter II. Obstructions are usually spoken of as "simple" or "strangulated," depending on whether or not the mesenteric circulation is constricted.

Simple Obstructions. In general it may be said that adhesions or bands bring about simple obstructions by compressing or flattening the intestine against some solid structure (Fig. 9)—such, for example, as the posterior abdominal wall or the scar of some previous abdominal operation—or by attaching loops to one another (see Fig. 5), to their mesentery, or to some other abdominal structure, thus distorting or pinching the intestine so that the lumen is occluded.

Strangulations. The fundamental methods by which these various structures produce strangulation are relatively few. In general this comes about in one of two ways: bands form bridges or arches, under which intestinal loops become engaged and strangulated; or long cords are formed into nooses or knots which capture a loop.

Strangulation under bands is the more frequent of the two types. All that is essential for the production of this type of strangulation is a firm band attached at two points to form

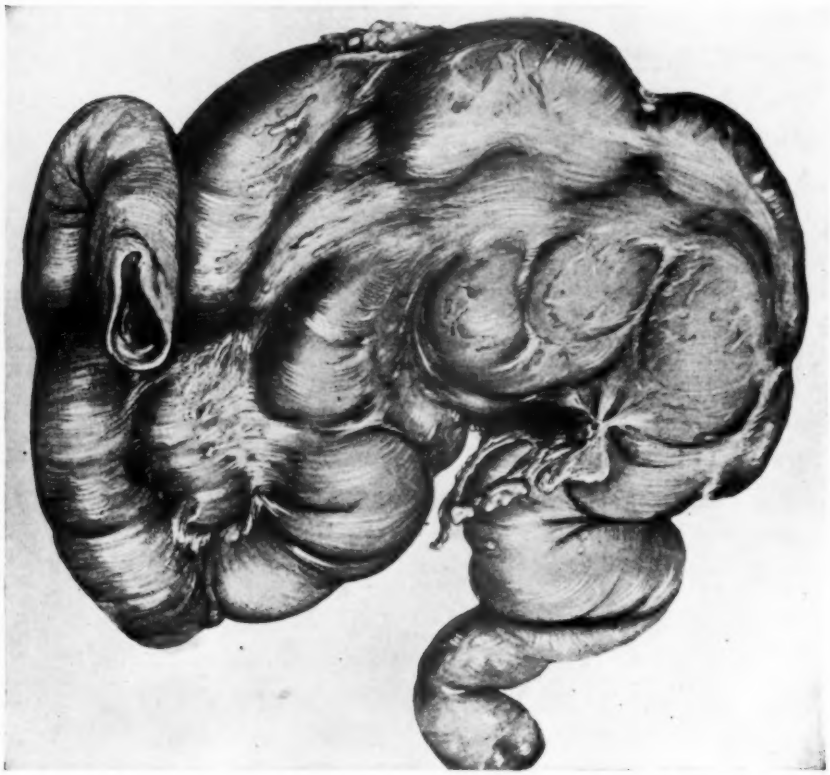

FIG. 8. Dense, investing, fibrous membrane, which has shortened, convoluted and angulated four-fifths or more of small intestine. (Dowd[2])

an arch, and a firm surface to make the floor of the arch. The points of attachment may be diverse: it is common for at least one end of the band to be attached to the mesentery; the posterior abdominal wall, the brim of the pelvis or the pelvic organs are also common sites of attachment. The bands are often multiple. They may be Y-shaped and the triangle between the arms of the Y may form the opening through which the loop of bowel passes. It is obvious that arches formed by bands have considerable similarity to the opening of a hernial ring, and the actual passage of the bowel through such an

opening and its subsequent strangulation is essentially similar to the strangulation of a bowel in a hernial sac, whether internal or external.

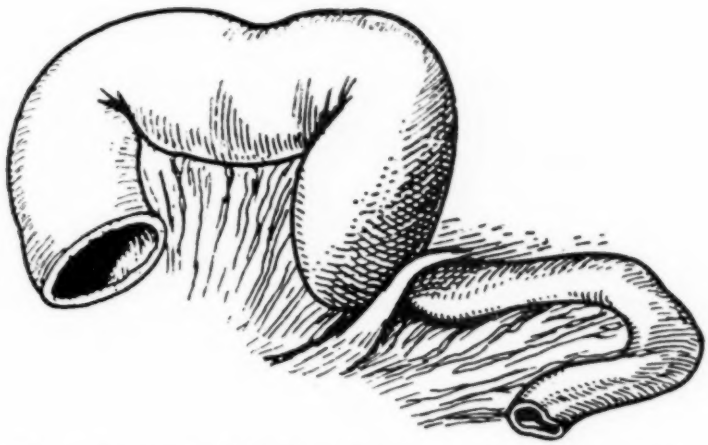

FIG. 9. Compression by isolated band. (Braun and Wortmann[9])

Long cords or bands lying within the abdominal cavity are capable of forming nooses and simple or complicated knots which may capture and strangulate a loop of bowel. Figure 6, A, B, C illustrates various ways in which this can come about. It will readily be seen that the pathological picture presented at operation or autopsy, in this type of obstruction, may be exceedingly complex and difficult to unravel; and it is obvious to what extent the mesentery must suffer with the bowel.

There are rare instances in which there is knotting or intertwining of intestinal loops themselves. According to Leichtenstern,[13] this most commonly involves the sigmoid flexure and a loop of ileum; although at times loops of small intestine only may be involved. Probably peritoneal adhesions or abnormalities of the mesentery are at the bottom of most of these cases.

Closely related to the above forms of strangulation are those in which a loop of bowel is trapped through openings in the mesentery, in the omentum or in certain ligamentary attachments normally present in the abdomen, as, for example,

the broad ligament of the uterus or the suspensory ligament of the liver. These are discussed under the heading of "Internal Hernias."

FIG. 10. Strangulation by solitary band attached at either end to mesentery. (Treves[10])

The exact mechanism by which strangulation comes about has been the subject of much study. There are doubtless many ways in which the initial compression of the mesenteric vessel, occurs. The band responsible for the strangulation is frequently attached to the mesentery, and relatively slight twists or torsions of the involved loop may be sufficient to hinder the mesenteric blood flow. Where a loop has become incarcerated under a band or through a hernial opening, distention may in certain cases be an important factor in causing the initial pressure on the mesenteric vessels, and at times draws more intestine through the hernial opening, thus increasing the amount of bowel involved. The course of events in such cases is as follows: a loop of bowel becomes trapped; gas is forced

into this incarcerated loop, and as it becomes distended a valve-like action takes place so that the gas does not escape;* as distention of the loop increases, more intestine may be

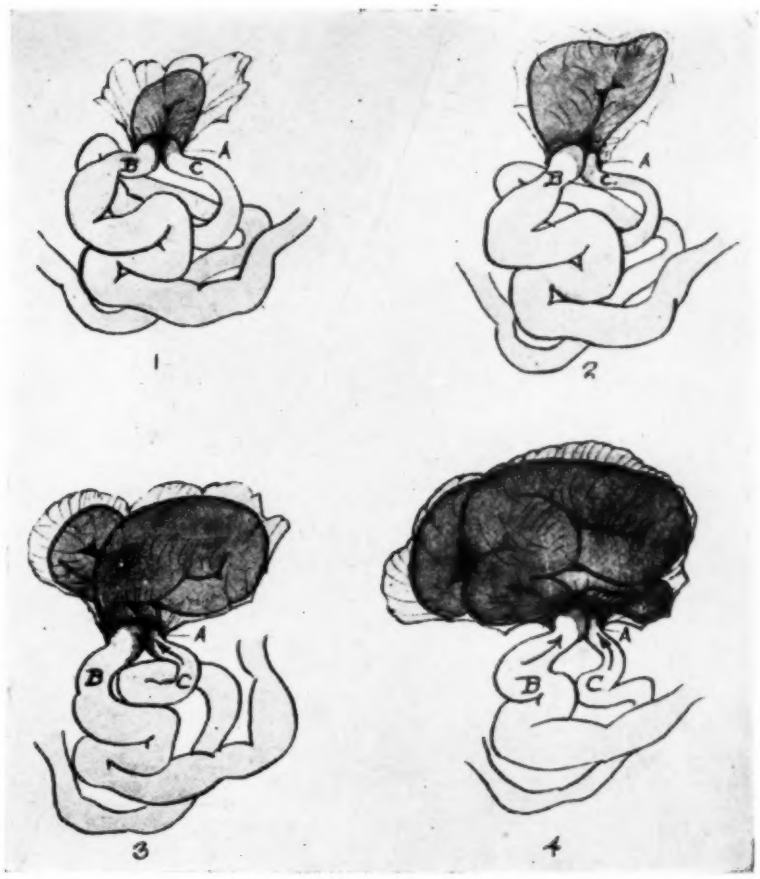

FIG. 11.

Gas trap mechanism. A, ring or band which constitutes opening into a pocket of peritoneum or mesentery. B, afferent intestinal loop and C efferent portion. In Diagram 1 process is just beginning; in diagram 2 bowel in pocket is overdistended by gas forced in from (B) and trapped by valve-like action of the ring; 3 and 4 show successive steps in inclusion and incarceration of bowel, as traction from pocketed and distended loop pulls more intestine into trap, as shown by arrows. (Gatch et al[18])

* The earliest experiments on this point were carried out by Bern,[14] who drew a loop of bowel through a small opening and found that if he blew air slowly through a catheter into one end of the bowel, it escaped easily through the other end; whereas if he suddenly blew in a large amount, the bowel became distended and none of the air escaped. (See also Rost[15] and Treves.)[16]

drawn into the trap (Anger,[17] Gatch,[18] and others) (Figure 11). As the process continues, pressure may be exerted on the mesenteric blood vessels; and it is clear that once this has

FIG. 12. Loop of small intestine strangulated beneath a Meckel's diverticulum. (Coley and Fortuine[11])

occurred the action will be progressive. First the thin-walled veins will be affected; engorgement of these vessels and subsequent edema of the mesentery and bowel wall will increase the pressure; and this in turn will further constrict the vessels. Under these conditions, an exudate quickly forms within the obstructed loop, which increases the distention and adds to the seriousness of the situation. The anoxemia of the strangulated loop will tend to set up violent peristaltic movements in the involved segment, which further complicates the

picture and perhaps accounts for the twists and torsions not infrequently found in connection with these internal strangulations.

Clinical Grouping of Obstructions by Bands and Adhesions. Obstructions caused by bands and adhesions form a large class (Figure 2, p. 179). Because of certain clinical and pathological differences, these cases are considered in three groups: obstructions occurring in patients who have had no previous operation; obstructions occurring late after operation; and those arising early after operation.

Obstructions in Patients Who Have Had No Previous Operation. The bands and adhesions in these cases are usually of congenital origin or the result of bacterial inflammation. Cases are reported in the literature where trauma to the abdominal wall was of sufficient severity as to injure the abdominal viscera and so produce localized peritonitis with adhesions which were later responsible for obstructions; but these cases are rare. In most instances it is impossible to determine, at the time of the operation for obstruction, the exact etiological factor responsible for the bands or adhesions, which usually represent anatomical landmarks of old, healed peritonitis. Tuberculosis is not infrequently a factor (see Case 1): among 21 cases recently reported,[19] mesenteric lymph glands, enlarged or partly broken down, furnished a chronic inflammatory focus in 5 instances; tuberculous peritonitis was present in one case; an acute, inflamed appendix acted as a band constricting the terminal ileum in one case.

In the afore-mentioned series, the obstructions were described as being due to adhesions in 13 instances; to bands in 8.* In 3 of these latter cases the omentum acted as a band. The mesenteric circulation was impaired in 8 instances, but in only 3 was it of sufficient severity to demand a resection.

* It is an interesting finding that when the obstruction was described as being caused by a band, the mortality was less than half as great as when it was described as due to adhesions. This applies also to obstructions occurring late after operation. The term "adhesions" was probably used to denote more widespread pathology; also a definite band is more easily dealt with at operation.

In this group of cases the obstruction was located in the small intestine in 16 instances; in the large intestine in 5.

The following is a representative case in this group of obstructions:

CASE 1. *Obstruction by bands and adhesions in a patient who had had no previous operation:*

No. 264,358, M. G. H. Male, aged seventeen. Patient complained of severe abdominal pain of eleven hours' duration, referred to the umbilical region; cramp-like in character, but present almost continuously; somewhat more severe on the left side of the abdomen than on the right. Had vomited shortly after onset of pain and several times since; vomitus was clear, bile-stained, odorless fluid. No bowel movements since the onset of the attack. Temperature 97.4°F.; pulse 50.

On physical examination there was some tenderness all over the abdomen, more marked on the left side; no distention; no visible peristalsis; no mass could be made out. Provisional diagnosis of intestinal obstruction with strangulation was made.

At operation there was a considerable amount of dark, bloody peritoneal fluid. A strangulated loop of ileum, dark and cyanotic in color, was found in the left side of the abdomen. The strangulation had been caused by a firm band attached to the mesentery and to a partially broken-down lymph gland ("presumably tuberculous") lying near the root of the mesentery. There was also a partial rotation of the involved coil.

The band was divided and the intestine liberated. Under observation the color improved; it was considered viable and returned to the abdomen. After a somewhat stormy convalescence the patient made a complete recovery.

Comment: The adhesions about the partially broken-down tuberculous lymph gland that were found in this case represent a not uncommon cause of obstruction.

Although this patient was operated upon within twenty-four hours of the attack, the viability of the bowel was open to some question; this illustrates the fact that a rapid course is run by cases of obstruction caused by acute strangulation; if operation had been delayed a few more hours a resection would have been required.

Late Postoperative Obstruction. Intestinal obstruction by bands and adhesions may follow any abdominal operation; it is most common after appendectomies for acute appendicitis.

In the recent Massachusetts General Hospital series of 45 cases, the original operation was as follows:

Appendectomy	27
Pelvic operations on uterus or adnexa	8
Repair of hernia (strangulated in 3 cases)	4
Miscellaneous	6

Since many of the appendectomies took place in other hospitals, it is impossible to estimate the number of cases that required drainage; the figures available, however, indicate that the number was probably high. In 7 instances the patient had undergone more than one operation before the obstruction occurred.

In the series of cases at the Massachusetts General Hospital, "late postoperative" is taken, somewhat arbitrarily, to mean four or more weeks after the original operation. These obstructions are more common during the first year after operation, but may occur at any time. In the 45 cases of this series, 16 occurred within the first year; the average interval, exclusive of the first year, was six years; the longest was twenty-five years.

Late postoperative obstructions are almost always in the small bowel. In the foregoing series the location was as follows:

Jejunum	2	
Ileum	19	
Small intestine (not further described)	22	43
Large intestine		2

Strangulations are not infrequent in connection with the old, thoroughly organized adhesions of this group. In the foregoing series of 45 cases, strangulation was present in 20 instances; among these a gangrenous gut was found and resected in 5 instances. A gangrenous gut requiring resection was also found in 2 cases of volvulus (listed under that heading) occurring late after operation.*

* Two other cases of volvulus occurred late postoperatively, but are listed under "volvulus."

The following case is representative of the late post-operative group:

CASE II. *Obstruction by bands and adhesions arising late after operation.*

No. 251,400, M. G. H. Female, aged twenty-three. Patient gave a history of appendectomy two years before admission; the wound had not been drained.

Two days before admission patient was seized with sudden, severe, cramp-like pain, described as being "all over the abdomen" but more severe over the upper half. On admission the pain was constant and severe. There had been vomiting shortly after onset of pain and a number of times since; the vomitus was not fecal in character. No bowel movements since the onset of pain. Temperature 98.6°F.; pulse 100; white blood count 26,000. Physical examination showed some tenderness across the lower abdomen; no visible or audible peristalsis. In view of these symptoms and of the fact that the patient had the scar of a previous abdominal operation, a diagnosis of acute intestinal obstruction was made. Immediate operation was advised, but was refused.

The morning after admission (twelve hours later) the patient consented to operation. On opening the peritoneum, dark-colored, bloody fluid escaped. The coils of the small intestine were greatly distended. The terminal ileum was obstructed by a band which crossed the bowel just above its entrance into the cecum; the mesenteric circulation was somewhat impaired at this point, but the bowel was considered viable. The obstructing band was cut and an enterostomy was performed a short distance above the point of obstruction. The patient made a satisfactory recovery from the anesthetic; but distention and vomiting persisted. The patient appeared to be very toxic and died the third day after operation.

Comments. The inciting cause of this obstruction was an adhesion resulting from the appendectomy of two years before. The patient came to operation late, in part due to refusal of operation on admission. The high white count of 26,000 was suggestive of strangulation.

The exact cause of death in this case is not clear from the data at hand. Apparently there was no return of peristalsis after the relief of the obstruction: possibly the bowel was paralyzed from the effects of obstruction and distention; it is also possible that a mistake was made as to the viability of the bowel where the band had compressed the mesentery.

General Comments. In the three Massachusetts General Hospital series,[19–21] the mortality in the group of obstructions by bands and adhesions where there had been no previous

operation was higher than it was in the group of "late postoperative obstructions." The suggestion has been made[20] that the presence of an abdominal scar made the diagnosis of obstruction easier and that for this reason the patients with postoperative obstruction came to operation earlier than those who had not been previously operated upon. In the latest series, however, the time element did not seem to be a factor in explaining the difference in mortality, for the patients without previous operation were, on the average, explored for obstruction earlier than the group with postoperative obstruction. The "late postoperative obstructions" operated on in less than forty-two hours after the onset of obstructive symptoms showed a mortality of 0 per cent; whereas the cases without previous operation, operated on for obstruction within the same period, showed a mortality of 37 per cent. It seems that the higher mortality must be explained on the basis of other characteristics of the two groups rather than on the time they came to operation. It should be stated in this connection that many of the obstructions by bands and adhesions without previous operation occurred in older individuals, and represent end-results of diverse pathological processes occurring at one time or another throughout life. The question of age alone probably does not explain the difference in mortality in these two groups.

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